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Cover Photograph: *Avicennia marina* By Manan Shukla

Editorial

Celebrating 125 Years of Publication

The *Journal of the Bombay Natural History Society* was first published in 1886 to collate and disseminate information on natural history of the Indian subcontinent and beyond. This year (2011), the *Journal* celebrates 125 years of uninterrupted publication (with some delays during World Wars due to paper shortage). The *Journal* was the most important medium to establish the credibility of the Society as a serious research organization interested in all aspects of natural history. For a long time, it was also the only publication of the Society to reach outstation members. List of animal specimens sent to the Society, list of members, donors and even annual financial reports, and minutes of annual general meetings were published in the *Journal* in the initial decades.

Besides research papers covering the Indian subcontinent that included Burma (now Myanmar) and Afghanistan, the *Journal* used to occasionally publish papers from the Middle East and West Asia. *Moths of Mesopotamia and N.W. Persia* by various authors, published in *JBNHS* 28 (1922) is one such example. In the same volume, *The Birds of Mesopotami* by C.B. Ticehurst, P.A. Buxton and R.E. Cheesman was published as a series. Another example is *Notes on Somaliland* by Captain P.Z. Cox published in Vol. 13, in two parts.

Detailed survey reports and accumulated work of many decades were published as a series, some running for many years. For example, E.C. Stuart Baker's *Indian Ducks and Their Allies*, was first published in Vol. 11(1) 1898 and ran in ten parts till Vol. 13(2) 1901. His other classical paper, *The Birds of North Cachar* was published from 1894 to 1901 in the *Journal*. Similarly, *Identification of Indian Butterflies* by Col. W.H. Evans was published as a series in the *Journal* and later as a book. Numerous papers in botany helped in documenting the floral wealth of India. For example, the paper *The Flora of the Indian Desert (Jodhpur and Jaisalmer)* by the famous botanists E. Blatter and F. Hallberg started in Vol. 26 (1918) and continued for many years. These seminal papers helped in establishing the foundation of natural history of the Indian subcontinent.

In the days of 'shikar', most advertisements were of natural history and *shikar* books, taxidermy, cartridges, rifles, etc., which obviously cannot be published now as hunting in India is totally prohibited. After Independence in 1947, the *Journal* became more insular and articles from neighbouring countries became fewer. The Society also stopped publishing advertisements in the *Journal*.

The earlier volumes of the *JBNHS* also carried advertisements. Internet revolution of the last two decades has made the world a truly large global village. We have therefore decided to revive the earlier scope of the *Journal*. From the coming volumes, the scope of the political boundaries for papers published in the *JBNHS* will not be limited to study conducted in the Subcontinent. The *JBNHS* will now carry reports of original research in natural history, taxonomy and other aspects of zoology and botany of general interest from across the globe. Scientists and naturalists working outside the Indian subcontinent can now submit their papers. *JBNHS* will also revive the tradition of publishing advertisements, however, these will be limited to products such as binoculars, telescopes, camera, field and lab equipment; this will help generate revenue for publishing the *JBNHS*.

The time scale between acceptance of a paper and its publication has also been reduced to 6-8 months, shorter in some cases. The referring system has been overhauled so now a paper will be peer-reviewed within a month. We hope that these changes will make the *Journal* more popular and expand its reach beyond the Indian subcontinent.

Asad R. Rahmani

■ ■ ■

CRITICAL OBSERVATIONS OF THE FAMILY AVICENNIACEAE FROM MAHARASHTRA AND GOA, INDIA

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Avicennia L. is a widely distributed mangrove genus exhibiting several morphological variations, as well as anomalies. These factors prove to be a constraint in the correct identification of a species and its varieties. The present work is an attempt to confirm the exact species composition of Family Avicenniaceae on the coasts of Maharashtra and Goa. The study deals with detailed review of available literature, herbarium studies and field observations for *Avicennia* sp. on these coasts. The present paper reports the occurrence of *A. marina* as a complex, and *A. officinalis* from Maharashtra and Goa. *A. alba* was not observed during the study. Some problems regarding the identification of existing species are also discussed. As a result, the paper also helps in proper identification of *Avicennia* species.

Key words: Avicenniaceae, *Avicennia*, Maharashtra, Goa, *A. marina*, *A. officinalis*

INTRODUCTION

Mangrove forests are made up of plant species that are taxonomically unrelated. They form the critical interface between terrestrial, estuarine, and near shore marine ecosystems in tropics and sub-tropical regions. *Avicennia* L. is considered as a major component of mangrove swamps throughout the world, playing a key role in community structure and having the ability to form pure stands (Tomlinson 1986). According to Duke (1992), there are at least eight species of genus *Avicennia* L. of which three occur in the Atlantic-East Pacific and five in the Indo-West Pacific.

Surprisingly, mention of *Avicennia marina* (Forsk.) Vierh. is absent in most literature available for India, while in some its presence is notified. However, *A. marina* is abundantly present on the coast of India, in general, and Maharashtra, in particular, then why does it not find mention in the earlier literature? Was it identified wrongly and designated other name? It appears that mistake in identifying the species by earlier workers is continued. Also, there are several disputes regarding the varieties of *A. marina*, as well as occurrence of *Avicennia alba* Blume in Maharashtra. Thus, the available literature, so far, seems to be incomprehensible and rather confusing.

The genus *Avicennia* L. grows on different eco-zones in the estuarine ecosystems (Duke 1991) resulting into wide range of variations in morphological characters of *Avicennia*, which are influenced by ecological and environmental, or genetic factors (Soto and Corralles 1987; Soto 1988; Duke 1990; Duke *et al.* 1998). Morphological variations tend to create confusion in identifying a species, as well as the varieties. Ample literature is available for *Avicennia* mainly based on herbarium studies (Moldenke 1960, 1967). But, Tomlinson (1986) suggested that it needs critical revision by means of field observations.

The present study claims an attempt to solve the taxonomic puzzle regarding *Avicennia* sp., and its exact status on the coasts of Maharashtra and Goa.

MATERIAL AND METHODS

An extensive survey of more than 100 populations of *Avicennia* sp. on the coasts of Maharashtra and Goa was conducted in different seasons. Vegetative as well as floral material was collected and morphological characters documented precisely. Authentic literature (Linnaeus 1753; Forskal 1775; Blume 1825; Wight 1850a, b; Hooker 1885; Talbot 1894, 1911; Moldenke 1960, 1967; Cooke 1967; Percival and Womersley 1975; Tomlinson 1986; Kulkarni 1988; Banerjee *et al.* 1989; Kothari and Moorthy 1993; Singh *et al.* 2001; Almeida 2003) was referred to for accurate identification and confirmation of the species and varieties of *Avicennia*. A thorough study of the herbarium specimens of *Avicennia* sp. deposited in the herbarium of Botanical Survey of India, Western Circle, Pune, was made. A comprehensive key and comparative chart is prepared for the species of *Avicennia* based on standard literature and critical field observations.

RESULTS AND DISCUSSION

The Indian Avicenniaceae comprises of three species of genus *Avicennia*, namely *A. alba* Blume, *A. marina* (Forsk.) Vierh. and *A. officinalis* L. (Kathiresan and Rajendran 2005). Recent literature tells of the occurrence of two varieties of

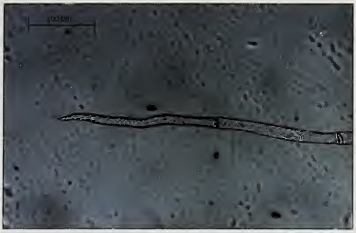

Fig. 1: Straight tip of Hypocotylar hair of *A. marina*

A. marina, these are *A. marina* var. *acutissima* Staf. & Moldenke ex Moldenke and *A. marina* var. *resinifera* (Forst.) Bakh. from India (Moldenke 1980; Singh *et al.* 2001; Bhosale 2005; Karthikeyan *et al.* 2009).

The confusion about the identification of *Avicennia* sp. in available literature makes it necessary to determine the exact species composition of *Avicennia* on the coast of Maharashtra and Goa. Unfortunately, the conditions in which *Avicennia* grows may vary from fresh to highly saline water and the change affects the tree considerably (Moldenke 1960). The morphological variations, particularly in leaves and flowers, were recorded by several workers (Bakhuizen van den Brink 1921; Watson 1928; Moldenke 1960, 1967, 1975; Tomlinson 1986; Duke 1990). Moreover, Shaikh and Chavan (2010) have observed morphological abnormalities in *A. marina* and *A. officinalis* on the coast of Maharashtra and Goa. *Avicennia* is a genus of mangroves attaining the size of a tree, it sometimes exhibits shrubby habit, but on the coast of Maharashtra and Goa a miniature form of 45 to 60 cm height can be seen. Flowering in seedlings is also reported from some localities (Shaikh and Chavan 2010). Classification based on morphological attributes depends on the extent to which an observer considers the variations to be stable. This may create controversy in correctly identifying taxa. Problem pertaining wrong identification was found in case of *Avicennia* of New Zealand (Lynch 1973).

Linnaeus (1753) reported the first *Avicennia* species *A. officinalis* from the Indian habitat. The distinguishing characters of *A. officinalis* are: obovate or broadly oblong leaves with rounded apex. Its ovary is entirely covered with long silky hair, with a shaggy style and bifid tapering stigma, much shorter than style (Bakhuizen van den Brink 1921). The species is documented for India by Wight (1850a, b) as *A. tomentosa*, but he supported Schauer's revival of the species as *A. officinalis*. Thus, thereafter, *A. tomentosa* is considered as a synonym of *A. officinalis*. The species has been reported from India by many workers (Hooker 1885; Talbot 1894, 1911; Vartak 1966; Cooke 1967; Rao 1986; Singh *et al.* 2001; Almeida 2003; Bhosale 2005; Kartikeyan *et al.* 2009). The critical field observations support the occurrence of *A. officinalis* along the coast of Maharashtra and Goa states.

According to Wight (1850a, b), there is another species of *Avicennia* found in India. He reported and illustrated it as *A. alba* Blume. He has denoted oblong elliptic-lanceolate leaves, acute at both ends, capitate flowers, and ovary densely hairy at apex as the marked features of the species. However, he has not described the fruit of this species. According to standard literature available, oblong lanceolate to lanceolate leaves, and ellipsoid or obliquely conic fruits are important characters of the species from the point of identification.

Hooker (1885) has reported *A. officinalis* from India. Instead of ranking *A. alba* as a separate species, he has documented it as a variety of *A. officinalis* and denoted it as *A. officinalis* var. *alba*. According to Hooker (1885) lanceolate leaves and short style or absence of style are the marked characters of this variety.

Talbot (1894) has reported a single species of *Avicennia*, i.e., *A. officinalis* from Bombay Presidency. He has reported *A. alba* along with *A. officinalis* in his FOREST FLORA OF THE BOMBAY PRESIDENCY (Talbot 1911). He has mentioned ovoid capsules as one of the prominent characters for *A. alba*, which does not match with the ellipsoid or obliquely conic fruits of *A. alba* mentioned in standard literature. Ovoid capsule is on the other hand the marked feature of *A. marina* and not of *A. alba*. Moldenke (1967) has accepted that the figure given by Talbot (1911) is actually a representation of *A. marina* (Forsk.) Vierh. He further added that *A. marina* has been misidentified and deposited in herbaria as *A. alba* and *vice-versa* several times (Moldenke 1975).

Cooke (1967) has also located *A. officinalis* and *A. alba* in the Presidency of Bombay like that of Talbot (1911). He too has wrongly described *A. alba* with an ovoid capsule. Taking into consideration, the above mentioned errors, it eventually proves that the vegetation in Bombay Presidency, which includes Maharashtra and Goa, is of *A. marina* and not of *A. alba*.

It is well-known that *A. marina* exhibits a wide range of morphological variations, especially in its habit and leaf shape. It also possesses higher degree of anomalies (Shaikh and Chavan 2010). These factors may lead to a misapplication of name to this species. *A. marina* and *A. alba* share some common characters such as actinomorphic flowers, short inserted stamens, hairy upper half of the ovary and short or nearly absent style. Hence, oblong-lanceolate leaves and

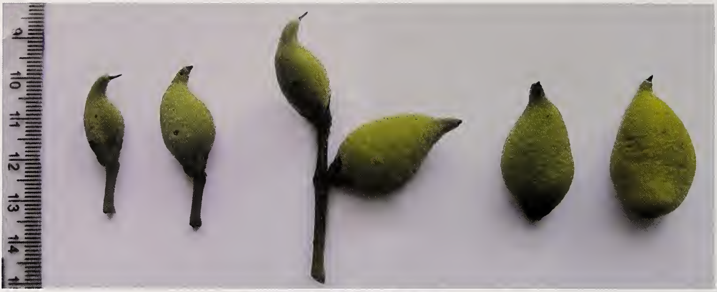

Fig. 2: Tricky fruits of *A. officinalis*

ellipsoid or obliquely conical fruits are the only characters that distinguish *A. alba* from *A. marina*. During the present survey, such kinds of fruits and leaves were not seen on the coast of Maharashtra and Goa; instead the fruits here were ovoid, which is the distinctive character of *A. marina*.

A. alba is reported to have hypocotylar hairs with hooked tips, which is a marked feature in its identification (Moldenke 1960, 1967; Tomlinson 1986). During the present investigation, hypocotylar hair of the vegetation was studied carefully and it was observed that their tips are not hooked, instead, they are straight (Fig. 1). It clearly points out that there is no presence of *A. alba* among the present vegetation on these coasts.

Yet some recent literature (Singh *et al.* 2001; Bhosale 2005) have documented *A. alba* from the coast of Maharashtra. According to Almeida (2003), Wight and Cooke were perhaps responsible for misidentifying the plants from Maharashtra. He adds that later literature has reported *A. alba* on the authority of Cooke (1967), which is a wrong record. Present field observations strongly support this fact. Regional literatures for Maharashtra and Goa (Vartak 1966; Rao 1986; Kulkarni 1988; Kothari and Moorthy 1993) have no records of the occurrence of *A. alba*.

The specimens of *Avicennia* sp. deposited in the herbarium of Botanical Survey of India, Western Circle, Pune, were critically studied for species confirmation. The study revealed that material deposited as *A. alba* represents characters of *A. marina*. Some experts have re-identified and labelled many herbarium specimens as *A. marina* var. *acutissima*, formerly named *A. alba*. There are very few specimens that distinctly show the features of *A. alba*, such as oblong-lanceolate leaves, but these were collected from localities such as Saurashtra and Kachchh on the coast of Gujarat. Unfortunately, the fruit, a peculiar character of the species is not at all preserved in any herbarium specimen. Almost all the material of *A. officinalis* is correctly identified. Fruits are also preserved in some herbarium specimens of *A. officinalis*. The study led to the conclusion that the material in the herbarium which was deposited from Maharashtra and Goa is composed of *A. marina* and *A. officinalis* only.

Similarly, controversies are also evident regarding the varieties of *A. marina*. Several varieties have been recognized, but morphological distinction is never clear and major segregation is geographic (Tomlinson 1986). Hence, without precise morphometry on widely separated populations, it is hardly possible to provide keys with reliable diagnostic characters.

Two varieties of *A. marina* are found to be present on the coast of Maharashtra, according to literature (Singh *et al.* 2001; Bhosale 2005). These are *A. marina* var. *acutissima* Staf. & Moldenke ex Moldenke and *A. marina* var. *resinifera* (Forst.) Bakh. *A. marina* var. *acutissima* has been given a rank of variety on the basis of its decidedly acute or acuminate leaf apex. As per present observations, on the coast of Maharashtra and Goa, every population of *A. marina* shows acute or acuminate apex of leaves. According to the authors of this variety, it is restricted to the vicinity of Bombay (now Mumbai). But, Almeida (2003) could not segregate this from the material collected from Bombay. This clearly indicates that the character stated above is not sufficient to designate the population as a separate variety.

Acute and acuminate leaf apices are also reported in *A. marina* var. *resinifera* (Tomlinson 1986). This is a matter of perplexity and needs critical morphometric observations as a solution.

Table 1: Diagnostic features of different species of *Avicennia* for proper identification

Features	*A. alba* Blume	*A. marina* (Forsk.) Vierh.	*A. officinalis* L.
Habit (Depends on ecological and environmental factors)	Tree or shrub.	Tree, shrub or miniature.	Tree or shrub.
Aerial roots	Present, well-developed.	Present, poorly developed, slender and short.	Present, well-developed, thick and stout.
Leaves	Oblong-lanceolate to lanceolate, rarely elliptic with acute or rarely obtuse tips and acute or rarely cuneate base. Whitish beneath.	Varying from ovate or lanceolate to lanceolate-oblong or elliptic with acute or acuminate rarely obtuse or rounded tips and cuneate base. Whitish beneath.	Obovate or broadly oblong with rounded apex and subcuneate or rounded base.
Inflorescence	Terminal and axillary panicles. Cymes spiciform or spicate composed of 10-30 opposite flowers.	Terminal and axillary panicles. Cymes capitate or subcapitate composed of 2-12 decussate flowers.	Terminal and axillary panicles. Cymes subcapitate or rarely elongated composed of 2-12 decussate flowers.
Flowers	Actinomorphic, tetramerous, orange-yellow coloured.	Actinomorphic, tetramerous sometimes abnormally pentamerous or hexamerous, orange-yellow coloured, yellow sweetly scented.	Slightly zygomorphic, tetramerous sometimes abnormally pentamerous or hexamerous, orange-coloured, with rancid or fetid smell.
Stamens	4, scarcely exerted, 1.5 to 2 mm long.	4 or 5 or 6, inserted, scarcely 2 mm long.	4 or 5 or 6, exerted, 3-4 mm long.
Carpel	Ovary ovoid or oblong; glabrous at base; densely hairy at apex (upper half), style short or nearly absent, stigma equally bifid.	Ovary ovoid or oblong; 2-3 mm long; glabrous at base; densely hairy at apex (upper half), style short or nearly absent, stigma equally bifid.	Ovary conic; 5 mm long; hairy throughout, style long; 3-4 mm; shaggy, stigma unequally bifid.
Fruit	Ellipsoid or obliquely conic, beakless.	Nearly spherical or ovoid, beakless.	Broadly ovate with prominent beak.
Seedling peculiarity	Hypocotyls teretely glabrous, hairy at extreme base. The hairs are with hooked tips.	Hypocotyls teretely glabrous, hairy at extreme base.	Hypocotyls throughout hairy. Abnormally show whorled leaves at each node.

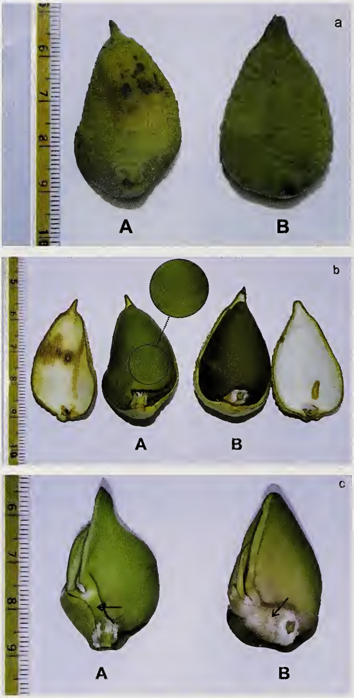

Fig. 3: The confusing characters of fruits in species of *Avicennia*

3a. perplexity in appearance of fruits
3b. trichomes on cotyledon surface of *A. marina*
3c. nature of Hypocotyl - a prominant identification mark
(A: *A. marina*, B: *A. officinalis*)

The upper half of the ovary is said to be hairy in *A. marina* var. *resinifera* (Moldenke 1960; Tomlinson 1986). During the present work, it was noticed that all the populations of *A. marina* on the coast of Maharashtra and Goa show the upper half of ovary as hairy. These populations exhibit a vast range in the shapes and sizes of leaves although. Hence, the acute or acuminate leaf apices and upper half hairy portion of the ovary should be considered as the features of *A. marina* (*A. marina sensu lato*). Thus, *A. marina* complex on these coasts should be considered as a single taxon. The ecological or regional varieties may come out of this complex only after prompt morphometric studies. Such scrutinized study for Maharashtra and Goa is in progress. The process of identification of any species or variety should not be biased, i.e., one must not rely on a single character of the concerned species or variety, instead multiple characters should be considered, as this will help to avoid unnecessary confusions. Table 1 depicts diagnostic features of *Avicennia* sp. from India and helps for proper identification. A comprehensive key is also provided for identification in field.

Thus, a thorough review of literature, prompt herbarium studies and critical field observations show that the Avicenniaceae in Maharashtra and Goa comprise of two species, namely *A. marina* complex and *A. officinalis*. Occurrence of *A. alba* is not found on these coasts.

Among the existing species, i.e., *A. marina* and *A. officinalis*, few tricking observations were recorded during the present study, which may create confusion in their identification if not analyzed well.

It is observed, on the coast of Maharashtra and Goa, that a few *A. officinalis* populations produce fruits which are obliquely conic in shape at the early development stages (Fig. 2). This particular shape occurs in *A. alba*. In such cases, a keen observation of the leaf and floral characters will avoid the confusion and resultantly wrong identification.

Besides, there arises another confusion regarding fruit shape and appearance. In case of *A. marina*, among some of its populations, the fruits resemble that of *A. officinalis* to a great extent. It is a rare case of course, but it also might mislead one regarding the identification. There are a few characters of the fruit, except the shape, which are strong enough to distinguish these two species (Fig. 3). In the fruit of *A. marina*, the surface of the outer cotyledon at the radical emergence facet bears multicellular silvery white trichomes with a pointed tip; this is absent in *A. officinalis*.

The fruits contain highly developed embryo in *Avicennia* species (Moldenke 1960). The hypocotyl in the fruit *A. officinalis* bears golden brown hairs throughout its length. But, in *A. marina* the hypocotyl is glabrous except at its base and the site of cotyledon attachment where silvery white hairs are seen. These are the additional characters that aptly befit for correct identification of the species.

KEY TO THE SPECIES OF *AVICENNIA* IN INDIA

1. Leaf blades usually whitish or silvery beneath, usually sharply acute at apex, ovary hairy at apex and glabrous below, mature fruit beakless 2

— Leaf blades usually not whitish or silvery beneath, obovate or broadly oblong with rounded apex, ovary hairy throughout, capsule broadly ovate or amygdaloidal with distinct beak. .. .. *Avicennia officinalis* L.

2. Leaves oblong lanceolate to lanceolate, cymes spicate, capsule ellipsoid or obliquely conic .... *Avicennia alba* Blume

— Leaves varying from ovate or lanceolate to lanceolate-oblong or elliptic, cymes capitate or subcapitate, capsule ovoid .... *Avicennia marina* (Forsk.) Vierh.

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SURVEY OF ISOLATED POPULATIONS OF THE NILGIRI TAHR *NILGIRITRAGUS HYLOCRIUS* (OGILBY) IN KERALA, INDIA

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We conducted a survey in Kerala from December 2009 to March 2010 to document Nilgiri Tahr *Nilgiritragus hylocrius* (Ogilby) populations in fourteen sites that ranged from Neyyar Wildlife Sanctuary in the southern Western Ghats to Silent Valley, north of the Palghat Gap. The total sightings of the Nilgiri Tahr over the course of the survey were 235 animals, of which yearlings and kids constituted 12%. Information from local sources indicated an estimate of about 500 in the area covered. The largest population of 76 animals was recorded in Neyyar Wildlife Sanctuary, besides small numbers in 8 sites. There were no sightings in Parambikulam Tiger Reserve and Siruvani hills. Habitat loss, due to colonization of grasslands by forests and plantation trees, was the major threat that affected all the sites to differing degrees. Human disturbance, accessibility, tourism, and poaching were other threats. Habitat management and stringent protection is critical for the long term viability of the Nilgiri Tahr.

Key words: Endangered species, India, Kerala, *Nilgiritragus hylocrius*, Nilgiri Tahr, small populations, Western Ghats

INTRODUCTION

The Nilgiri Tahr *Nilgiritragus hylocrius* (Ogilby) is an endangered mountain ungulate endemic to the Western Ghats with a distributional range of about 400 sq. km, in the southern Indian states of Kerala and Tamil Nadu. From the first systematic census in the Nilgiris, where 292 animals were sighted (Davidar 1963), it was already clear that poaching, human presence, and plantations were a threat to this animal. The first map of the Nilgiri Tahr range was outlined by Schaller (1970) who visually recorded 640 animals in several areas he visited and estimated their total number to be less than 1,500. Between 1975 and 1978, Davidar (1978) surveyed most of the species' range and estimated the total number at 2,230, in 17 areas. Later, Rice (1984) noted that of the 17 sites in which the Nilgiri Tahr has been recorded, only two supported populations of over 100 animals. The largest population is found in Eravikulam National Park (NP), in Kerala. The number of Tahr in this place remained relatively stable: 500 according to Schaller (1970), 700 according to Davidar (1978) and 696 according to Abraham *et al.* (2006). The second largest population in the Nilgiris was originally estimated to be about 300 in 1969 (Schaller 1970) and around 450 between 1975 and 1978 (Davidar 1978), and since appears to have declined in the 1990s (Sumitran 1997). Other population assessments have been by Mishra and Johnsingh (1998), who estimated about 1,400 animals in Kerala, including Eravikulam NP. Alembath (2002) in his study in Periyar Tiger Reserve (TR) recorded 16 animals in the Mangaladevi region, and Abraham *et al.* (2006) in their most recent survey in 2001 stated that the tahr population in Kerala was highly fragmented, and estimated a population of 998 animals. Our present objective was to survey the areas with smaller populations in Kerala, as they are at a greater risk of extinction.

METHODS

The survey was carried out from December 2009 to March 2010. Fourteen sites were visited (Table 1). The sites ranged from Neyyar Wildlife Sanctuary (WLS) in southern Western Ghats at 08° 33' N to Silent Valley at 11° 12' N. The sites ranged in altitudes from 820 m above msl in Ponmudi to 2,420 m above msl in Munnar in the high ranges (Fig. 1).

Direct sightings, pellets, hoof marks, urine stains, presence of fire were recorded during the study. An effort was made to identify the herd structure and classify them by age and sex with the help of binoculars. This information was corroborated with supporting information from local sources and naturalists. The geographic coordinates of the site, altitude, level of access by roads, indications of human disturbances and poaching were noted.

The herd size and composition were noted when possible using guidelines by Rice (1984): (i) Young: age 0-1 years, grey brown or light brown coat; (ii) Yearling: age 1-2 years, grey brown coat. Intermediate in size between young and adult females; (iii) Adults: since the males and females could not be differentiated because of lack of powerful binoculars, we classified them generally as adults; (iv) Saddle back (male): age 6+ years. Dark brown coat, with an area of light brown white or silvery hair covering the lower back rump and or flanks. Carpal patches white.

The level of disturbance caused by humans, poaching, impact of tourism and habitat losses were considered to be potential threats and ranked as 0 (nil), 1 (low), 2 (medium), 3 (high) and 4 (very high). No actual measurement was made on these variables. However, disturbance reflected distance to the nearest road/habitation, poaching assessment was based on witness accounts, impact of tourism was ranked according to the presence or sign of presence of visitors, and habitat loss was estimated from age of plantations and informal questions to villagers. We used Spearman's Rank correlation to look at the association between levels of disturbance with tourism, poaching, road access and habitat quality. The analysis was conducted using Systat (SPSS 2000).

RESULTS

The total sightings of the Nilgiri Tahr over the course of the survey were 235 animals, of which the largest category was not classified to age or sex (Table 2). On the whole young animals, which are easier to classify, constituted 12% of the population, which indicates a healthy replacement level. Information from local sources suggests that there could be

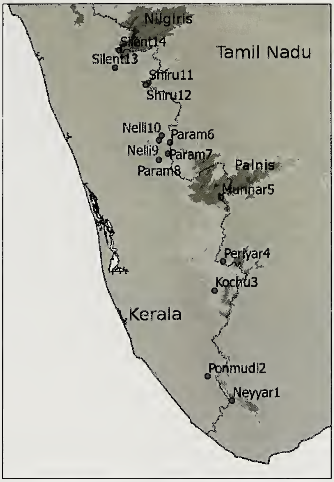

Fig. 1: Sites surveyed during the study

Table 1: Details of the sites surveyed

Site Ref.	Site	Range	Location	Lat. (N)	Long. (E)	Elevation (m)
Neyyar1	Neyyar WLS		Varayattumudi	08° 33'	77° 17'	1,420
Ponmudi2	Ponmudi RF	Palode range Trivandrum Division	Varayadumottai	08° 44'	77° 06'	820
Kochu3	Kochu Pamba RF	Goodrical Range Ranni Division	Varayadukokkai	09° 23'	77° 09'	1,180
Periyar4	Periyar TR		Mangaladevi	09° 36'	77° 13'	1,330
Munnar5	Munnar Hills RF	Devikulam range Munnar Division	Kolukkumalai Meesapuli Malai - Silent Valley Plateau	10° 05'	77° 12'	2,420
Param6	Parambikulam TR		Pandaravarai	10° 30'	76° 49'	1,209
Param7	Parambikulam TR		Vengoli Malai	10° 25'	76° 48'	1,000
Param8	Parambikulam TR		Karimala Gopuram	10° 22'	76° 44'	1,430
Nelli9	Nelliampathy Hills RF	Nelliampathy range Nenmara Division 1	Kurisumalai Hilltop	10° 31'	76° 44'	1,260
Nelli10	Nelliampathy Hills RF	Nelliampathiy range Nenmara Division 1	Mampara Minnampara	10° 33'	76° 45'	1,336
Shiru11	Siruvani Hills RF	Agali range Mannarkkad Division	Kunjara Malai	10° 57'	76° 39'	1,400
Shiru12	Siruvani Hills RF	Agali range Mannarkkad Division	Elival Malai	10° 56'	76° 38'	1,480
Silent13	Silent Valley NP		Neelikkal Vannampara	11° 04'	76° 24'	1,087
Silent14	Silent Valley NP		Ankinda Malai New Amarambalam	11°12'	76° 26'	2,040

Note: Geographic coordinates indicate approximate places of observation about 500 animals in the area surveyed.

The largest population of Nilgiri Tahr was recorded in Neyyar WLS (Table 2). Other sites with populations over 40 animals were in Munnar and Kurisumalai-hill top in Nelliampathy. Small herds were sighted in Mangaladevi in Periyar TR, Mampara and Minnampara in Nelliampathy, and Neelikal and Vannampara in the Silent Valley NP. No tahrs were sighted in Parambikulam TR and Siruvani hills (Table 2).

Habitat loss was the major threat overall, both in occurrence and intensity. Habitat loss affected all the sites to differing degrees (Table 3). It was a major threat in Parambikulam TR and Silent Valley NP and to a lesser threat in Neyyar WLS, Kochu Pamba, Periyar, and Elival Malai in the Siruvani hills, and Ankinda Malai in Silent Valley NP (Table 3). Habitat loss is caused by loss of grasslands due to expansion of forests or monoculture plantations.

Levels of human disturbance were highest in Ponmudi RF and in Mampara and Minnampara in Nelliampathy. The Neyyar WLS, Kochu Pamba RF, and Ankinda Malai in the Silent Valley NP were fairly undisturbed (Table 3). An indicator of human disturbance was the presence of motorable roads <1 km from the tahr habitat. Sites in Neyyar WLS, Parambikulam TR and Silent Valley NP had low levels of human disturbance. Tourism and poaching were other major threats and were highly correlated with human disturbance (Table 3). Human disturbance levels were positively correlated with increasing levels of poaching ($r_s=0.50$, n=15, $p<0.05$), tourism ($r_s=0.68$, n=15, $p<0.05$), and negatively correlated to distance from the nearest town ($r_s=0.52$, n=15, $p<0.05$). Accessibility by roads (km) was positively correlated with tourism threat ($r_s=0.48$, n=15, $p<0.05$).

Table 2: Number of Nilgiri Tahr sighted in the different sites

Site Ref.	SB	Adult	YLNG	K	UI	Total
Neyyar1	6		8	2	60	76
Ponmudi2					11	11
Kochu3		2	3	2	15	22
Periyar4			2		4	6
Munnar5	2	4	3		37	46
Param6						0
Param7						0
Param8						0
Nelli9		3	4	3	40	50
Nelli10					7	7
Siru11						0
Siru12						0
Silent13	3					3
Silent14		2		2	10	14
Total	11	11	20	9	184	235

SB: Saddle back, Adult: male and female, YLNG: yearling, K: kid, UI: unidentified

Table 3: Estimates of threat levels due to different causes

Site Ref.	Human disturbance	Poaching	Tourism	Habitat loss	Total
Neyyar1	0	1	0	1	2
Ponmudi2	4	2	2	2	10
Kochu3	1	0	1	1	3
Periyar4	2	1	1	1	5
Munnar5	2	1	1	2	6
Param6	0	0	1	4	5
Param7	1	2	1	4	8
Param8	0	1	1	2	4
Nelli9	2	2	2	2	8
Nelli10	3	2	2	2	9
Siru11	1	1	0	2	4
Siru12	1	2	0	1	4
Silent13	2	2	0	4	8
Silent14	0	0	0	1	1
Total	19	17	12	29	
Number of sites	10	11	9	14	

Poaching was detected in all sites except Kochu Pamba RF, Pandavarai in Parambikulam TR and Ankinda Malai in the Silent Valley NP (Table 3). Unregulated tourism was a threat in most of the sites except Neyyar WLS, Siruvani hills and Silent Valley NP. Motorable roads increased access to the sites and increased levels of human disturbance, tourism and poaching.

DISCUSSION

This survey indicates that most of the small populations of the Nilgiri Tahr in Kerala are under threat. We recorded 235 Nilgiri Tahr in 14 locations in Kerala. These were areas that had been surveyed earlier (Davidar 1978; Abraham *et al.* 2006). Of the 14, only three sites, Neyyar WLS, Munnar hills and Kurisumalai-hill top in Nelliampathy, held over 40 tahr. Most of the records were of one small herd. In some places, we did not see any animals. Parambikulam TR and Siruvani hills are sites where tahr had been recorded earlier, but none were sighted during this survey (Davidar 1978; Abraham *et al.* 2006).

Upon evaluating the levels of threat in each site, we found that the highest threat level was due to habitat loss. Habitat loss is due to the decrease of grasslands because of natural expansion of forests, or due to the installation of monoculture plantations in the grasslands. One of the reasons for the forest expansion could be because of lack of fire in the grasslands. However, this has to be tested with experimental fires at the earliest so that the loss of tahr habitat could be reversed.

In some sites, we did not record any tahr; for example, Davidar (1978) and Abraham *et al.* (2006) recorded 22 tahr and 4 tahr (2 adults and 2 yearlings), respectively in Pandavarai in Parambikulam TR. In Karimala Gopuram, which lies inside Parambikulam TR, Davidar (1978) reported 120 animals in the 1970s, Abraham *et al.* (2006) recorded nine animals: five adult females and four subadults in 2001. We did not see any animals, but few signs of tahr such as pellets were sighted. Davidar (1978) estimated a population of 20-25 animals in Vengoli, and Abraham *et al.* (2006) recorded one saddleback. The status of the Vengoli population is unclear. This population moves between Kerala and Valparai in Tamil Nadu. There were no recent sightings of tahr in this area according to local sources and prior surveys (Mammen pers. comm.). Senior tribal forest guards informed us that the forests had overgrown the tahr habitats due to lack of fire, which could have negatively affected the tahr populations, since they become more susceptible to ambush by predators such as tigers and leopards. Tribal sources also informed us that the grasslands were more extensive decades ago in Parambikulam-Thunakadavu area and due to forest incursion, much of the tahr habitat had been lost. Levels of human disturbance were highest in Ponmudi RF, and in Mampara and Minnampara in the Nelliampathy. Private estates and unresolved claims over land ownership pose severe threat to the existence of tahr in Mampara and Minnampara.

In the Siruvani hills, we did not record any tahr, but fresh and old pellets were noted. Earlier surveys by Abraham *et al.* (2006) had recorded 11 animals in Elival malai, and signs of a larger population in Kunjara malai.

The population in Nelliampathy seems more stable and we recorded about 50 animals in Kurisimala-hill top, whereas Abraham *et al.* (2006) had recorded 37. However, levels of human disturbance remain high, and in the past (Abraham *et al.* 2006) livestock grazing and poaching appear to be major threats.

Overall the young tahr constituted 12% of the population, which indicates that there is a healthy replacement of population. However, it is important to note that habitat loss is a major threat, and roads which facilitate easy access to tourists, and pilgrimage centres within Nilgiri Tahr habitats will increase the pressure on the habitat and will ultimately lead to the decline and eventual extinction of small vulnerable populations of this highly endangered mountain ungulate.

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PHYSICAL AND BIOLOGICAL IMPACT ON MARINE BENTHIC POLYCHAETES DUE TO DREDGING IN THE MORMUGAO HARBOUR, GOA AND ITS RESTORATION AFTER DREDGING

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Recolonization of benthos following dredging operations was studied in Mormugao Port Trust Harbour, Goa. Six stations were fixed for sampling within the radius of the dredging site. Three samples each were collected during dredging and after dredging. The proportion of gravel in the sediment of the dredged site increased after dredging, while that of organic matter decreased. The impact on community was estimated at species level, using both univariate and multivariate analyses. Maximum negative effect was observed during dredging where a reduction by 60-70% on macrofauna was evident. Within six weeks after dredging the density of the polychaete *Clymene annadalei* increased in the dredging site, while typical 'opportunistic' species such as *Capitella capitata* was not favoured by dredging. Favourable condition for resettlement of benthic communities is probably available in about four months.

Key words: Recolonization, dredging, benthos, harbour, impact

INTRODUCTION

Dredging operations in harbours are long-established human-induced disturbances. The impact of dredging is often considered to be similar to trawling as both are towed across the surface sediments where they are likely to damage the organisms near the surface (Morton 1977). These topographic changes persist longer in deeper and more sheltered waters, which are less exposed to wave action (Jones 1992). Impact of dredging/fishing has been well-documented; however, biological impacts are particularly difficult to investigate because of the complexity of benthic communities and our limited knowledge of its natural variability (Gislason 1994). Dredging reduces seagrass abundance and replaces the habitats to unvegetated sand flats (Peterson *et al.* 1987).

These anthropogenic perturbations usually drastically reduce the benthic population and temporarily change the environmental abiotic features (Pranovi *et al.* 1998). Spatio-temporal variations in abiotic and biotic parameters in this estuarine system are affected by tropical monsoon; riverine and tidal flows make them ecologically complex system (Harkantra 1975; Parulekar *et al.* 1980; Qasim and Sen Gupta 1981; Harkantra and Parulekar 1985; Rathod *et al.* 1991; Shetye *et al.* 1995)

Although the effect of dredging and disposal of dredged material have been relatively well-documented (Giovanardi *et al.* 1998; Lewis *et al.* 2001), subsequent recolonisation is a site-specific process, with both time and spatial scale involved. Further, recolonization depends upon the local hydrodynamic and sedimentary conditions (Guerra-Garcia *et al.* 2003). In most dredging instances, the magnitude and locations govern the impact of possible ecological disturbances. Existence of control sites with similar sediment characteristics, depth and benthic community to the dredge site is not always easy to find, and this restricts the accuracy of many studies.

The objective of this study was to examine the impact of dredging on benthic community, sediment characteristics, decolonization and possible reason to evaluate the effectiveness of recovery in a tropical harbour.

MATERIAL AND METHODS

The study area – Mormugao Port – is located at the mouth of river Zuari (15°25' N; 73° 47' E; Fig. 1). The harbour is located between two bays connected by a channel, which is 4.6 km long with increased water movements across and around the middle of the harbour. It is one of the six important major ports along the west coast of India. In early 1950, it handled limited cargo, whereas today major developmental changes have taken place and the harbour handles substantial quantities of cargo, ore and oil. It is characterized by intense shipping traffic, and frequent loading and dumping is involved in shipping operations. Existence of vast iron ore reserves in Goa helped to grow into a major export harbour having an annual traffic of over 14 million tons. The depth in the harbour ranges between 3 to 14 m.

The annual siltation in the channel, which mostly occurs during monsoon is about 34 lakhs cu. m. With the changes in shipping trends the approach channel requires to be deepened and continuously maintained to a desirable depth to cater to deep draft-vessels, such as oil tankers, bulk cargo vessels and ore carriers.

Table 1: Species density n/0.04 sq. m (average of triplicate samples) at different sites and months

Months/Polychaete species	Stations					
	1	2	3	4	5	6
April						
Prionospio pinnata	71.8	44	48	69	82	79.6
Clymene annadalei	23.7	21	64.6	3.9	13.3	55.6
Lumbriconereis sp.	1.3	0.4	0	0	0	0
Nephthys inermis	0.3	0	0.3	0	2.7	2
Nereis capensis	2.7	0	1.6	0	0	1.4
Megalona sp.	0	0	2.4	3.3	0	0
Capitella capitata	8.8	12.4	0	17.1	0	0
Glycera alba	0	0	3.4	0	4.7	2.1
Number of Species	6	4	6	4	4	5
May						
Prionospio pinnata	0.9	10	0	0	4	17
Clymene annadalei	0	4	0	0	2	8.7
Lumbriconereis sp.	0	0	0	4.8	0	0
Nephthys inermis	8.6	0	0.8	0	2.3	0.7
Nereis capensis	0	0.9	0	3.6	0	0
Megalona sp.	0	1.8	0	0	0	0
Capitella capitata	0	2.3	0	0	0.7	0
Glycera alba	0	0	0	0	0	2.4
Number of Species	2	5	1	2	4	4
June						
Prionospio pinnata	5	0	0	3.6	0	1.1
Clymene annadalei	1.9	0	0	0	2.8	4.9
Lumbriconereis sp.	0	0	0	0	0.4	0
Nephthys inermis	0	0.8	0	0.2	0	0
Nereis capensis	6.4	0	0	0	0	1.2
Megalona sp.	0	0.7	0	0	0	0
Capitella capitata	4.4	0	0	0	0	0.3
Glycera alba	0	0	3.9	0	0	0
Number of Species	4	2	1	2	2	4
August						
Prionospio pinnata	56.6	33	49.9	21.3	36.4	29.8
Clymene annadalei	56.2	56.6	29.4	91.4	104.4	91.6
Lumbriconereis sp.	2.3	15.2	0	0	1.1	0
Nephthys inermis	0.6	0	0.3	0	10.3	0
Nereis capensis	20.1	0	0	3.3	0.7	0.4
Megalona sp.	0	0	2.3	0	0	0
Capitella capitata	3.9	6.9	3.1	0	0.9	19.3
Glycera alba	0.6	0	0.3	3.6	0	0
Number of Species	7	4	6	4	6	4
October						
Prionospio pinnata	76.2	146.6	69.4	91.4	97.4	91.6
Clymene annadalei	66.6	93	79.9	71.3	36.4	29.8
Lumbriconereis sp.	4.3	15.2	0	9	1.1	0
Nephthys inermis	0.6	3.1	0.3	3.1	10.3	0
Nereis capensis	20.1	0	0	3.3	0.7	0.4
Megalona sp.	1.1	0	2.3	0	0.9	0
Capitella capitata	2.3	6.9	3.1	0	0	5.3
Glycera alba	0.6	0	0.3	3.6	0	1.1
Number of Species	8	5	6	6	6	5

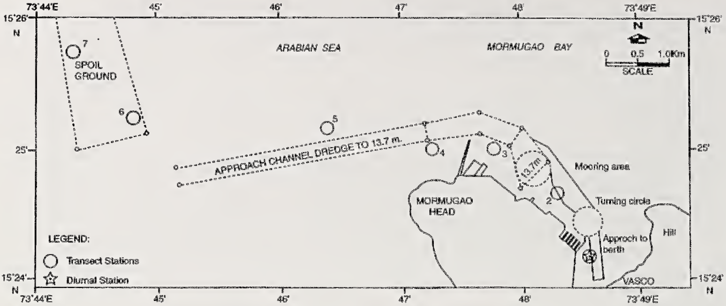

Fig. 1: Schematic diagram of the stations studied at Mormugao Port Trust Harbour

In the Mormugao Harbour, dredging was carried out in the approach channel, turning circle, and mooring buoy berths (Fig. 1). Port Authority began dredging soon after our first sampling (pre-dredging sample), i.e., at the end of April. Samples were collected before, during and after dredging between April and October 2009. Seven stations were fixed. Stations, 1-5 were within 100-200 m radius of the dredging area, and Station 6 and Station 7 at 5 km and 7 km respectively. The seventh station was a dumping yard. Samples collected in April were considered as baseline data. Three samples were obtained from each site with a van Veen grab; sediment penetration was never less than 20 cm. Sediment samples from the grab were preserved in 10% formalin in sea water and Rose Bengal stain mix. Later, these samples were sieved through 0.5 mm mesh size; samples retained on the sieve were transferred to plastic containers and preserved in 5% formalin in sea water (Eleftheriou and Holme 1984). Macrofauna were identified at species level and each species was counted under the stereo zoom microscope. Population density was converted to 0.04 sq. m. One grab was used for analyzing sedimentary characteristics and organic matter analyses following standard procedures. The organic matter obtained from samples of sediment previously dried at 100 °C over 24 hour, was analysed by ashing to 500 °C (Eleftheriou and Holme 1984). Granulometry was determined by Buchanan and Kain's method (Buchanan and Kain 1984).

Univarite analyses provided the total number of species, total abundance, Shannon-Weiner diversity and Pielou's evenness indices (Shannon and Weaver 1963; Pielou 1966), and the Margalef index (Margalef 1958). Using the values of the triplicates (0.04 sq. m), the possible variations of these community descriptors were tested with one-way ANOVA, after verifying normality using the Kolmogorov-Smirnov test and Bartlett test for homogeneity of variances.

RESULTS

The data for environmental parameters is presented in Fig. 2 a and b. The macrobenthic organisms because of their limited mobility form an important indicator of the prevailing environmental conditions in a locality. They play an important role in biogeochemical processes, pollutant metabolism, and secondary production (Snelgrove 1998). Earlier studies have suggested that benthic fauna of a dredged area differs from that of a non-dredged area with respect to species composition (Newell *et al.* 1998).

Table 1 shows spatio-temporal distribution of benthic polychaete species. The fauna was composed mainly of polychaetes and dominated by *Prionospio pinnata* followed by *Clymene annadalei*. During the present study, eight species were recorded among the local benthic fauna. Species density varied with sites and months; density of *Prionospio pinnata* 146.6/0.04 sq. m (station 2) being highest, which was recorded in October (Table 1). This indicates the small scale spatio-temporal heterogeneous variation of soft-bottom dwelling macro-invertebrates (polychaeta). This could be attributed to the perturbation in the environment due to dredging. The abundance, number of species, species richness, evenness and indices started to re-adjust 42 days after dredging (Figs 3 a-e). After dredging, polychaetes, especially *Clymene*

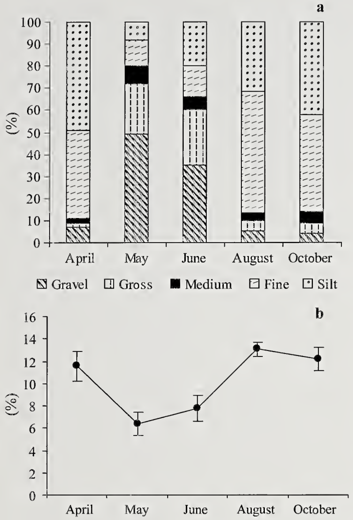

Fig. 2: (a) Sediment granulometry (b) organic matter
Values are averages of 6 samples taken during April-October.
Median grain size ranges Gravel: 2 mm; gross-very gross sand: 0.2-2 mm; medium sand: 0.25-0.5 mm; fine-very fine sand: 0.065-0.25 mm; silt-clay: Me < 0.065 mm. Organic matter mean values with standard error.

annadalei, drastically increased in the dredged site, while opportunistic species, such as *Capitella capitata*, were present in low abundance (Table 1).

Table 2 represents species diversity index, evenness and richness. The result of two-way ANOVA between stations and species in different months (Table 2) showed significant differences for all variables. The result of 1-way ANOVA of macrofaunal abundance showed variation between sampling months and stations. Abundance of macrofauna was not very rich during May and June. A positive and significant relation between the species and non-significant relations between stations were found in April, August and October. April and October also show no significant variation indicating that the community has returned to pre-dredging values.

Table 2: F-ratios obtained through Two-way analysis of variance (ANOVA) between stations and between species

Months	April	May	June	August	October
Source of variation					
Between stations					
n_1=5	0.4	1.34	1.24	0.458	1.09
n_2=35	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p < 0.05$	$p < 0.05$
Between species					
n_1=7	27	1.87	0.87	24.90	30.43
n_2=35	$p < 0.001$	$p < 0.05$	$p < 0.05$	$p < 0.001$	$p < 0.001$

DISCUSSION

This study documents the impact of dredging operations on a soft-bottom community by the changed sediment structure as well as by the depletion of organic matter. Dredging caused initial decrease in macrofaunal abundance, biomass and species number. Similar studies have been reported by Lopez-Jamar and Mejuto (1988) and Guerra-Garcia *et al.* (2003) from elsewhere. A number of species, especially burrowing polychaetes and fragile groups, such as nemerteans, were probably killed and cut by dredging. Others may have been affected by high turbidity, high rates of sedimentation, or were buried when depressions were filled (Black and Parry 1994). Due to these changes, species diversity and individuals reduced to 80-90%. As per Newell *et al.* (1998), diversity is expected to reduce by 30-70% and species abundance by 40-90%. In the present study, the macrofaunal community showed quick recovery (4 months). Recovery of lost community in a dredged area may take a few days to years depending upon the intensity of dredging, the hydrodynamic condition of the dredged area, sediment texture and macrofaunal community (Pranovi *et al.* 1998).

Changes in relative distribution of major benthic groups following dredging abatement have been noted earlier (Johnson and Nelson 1985; Hily and Glemarec 1990). However, these do not appear to follow a consistent pattern, and are presumably habitat and community specific. In addition, it has been noted that certain taxonomic groups appear to be more affected by dredging than other groups (Morton 1996), although this may be habitat, location and/or community specific.

Macrobenthic community was recorded after cessation of dredging. This is in contrast to many studies, which report a near complete defaunation in active dredging areas (Johnson 1981). The formation of undisturbed "hummocks" of undredged material during dredging have a high biological significance in the process of repopulation by the indigenous benthic community within the dredged area (McCauley *et al.* 1977). This recolonization results from the migration of adults or by larval establishment (McCauley *et al.* 1977). Zajac *et*

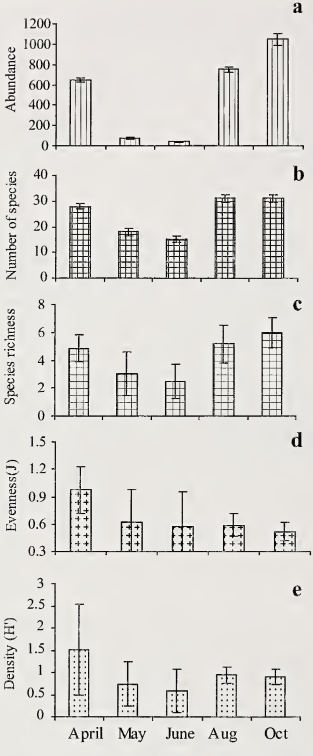

Fig. 3: Trend of abundance (a) species number, (b) species richness, (c) species evenness and species diversity (d) during different months during the study period. Mean values and standards errors are included

al. (1998) pointed out that the relative combination of factors controlling re-colonization and successional process may be different depending on the spatial scale.

Considering the fact that Mormugao harbour is tide dominated, with waters being well mixed, the benthic colonization was probably through water column (larvae and /or adults) (Guerra-Garcia *et al.* 2003). Further, cessation of dredging was followed by monsoon season which facilitated faster recolonization of the dredged site by the new recruit from the surrounding areas.

A variety of abiotic and biotic factors, including human perturbation (McCall 1977; Trueblood *et al.* 1994), affect the benthos. The community was represented by early colonizing species, such as the opportunistic Maldanidae polychaete *C. annadalei* and *P. pinnata*. A major structuring force in colonization of benthic fauna was the response of species to resources released from sediments by periodic disturbances (Rhoads and Boyer 1982). Biotic habitat modification by earlier species may also enhance the settlement of subsequent species, which suggest the facilitative mechanism of succession that can occur in soft-bottom communities (Zajac *et al.* 1982). Tropical monsoon in estuaries brings about defaunation and drop in salinity triggers reproduction in most benthic organisms followed by recruitment during post monsoon season (Harkantra and Rodrigues 2003).

The polychaete *Capitella capitata* is one of the most common species known to be highly tolerant to polluted areas. It can also be considered as one of the global opportunistic species in disturbed marine sediment (Estacio *et al.* 1997; Newell *et al.* 1998). In the present study, the species was present in less abundant after dredging. The changes in sediment characteristics and reduction in organic matter, could have affected recolonization of *C. capitata*. Changes to community structure caused by dredging were smaller and allowed quick re-adjustment of the initial sediment structure and benthic communities.

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CIRCUMSTANTIAL AND RESPONSE ATTITUDES OF PEOPLE AFFECTED WITH LIVESTOCK DEPREDATION BY LEOPARDS *PANTHERA PARDUS* LINNAEUS IN RATNAGIRI DISTRICT, MAHARASHTRA, INDIA

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Livestock depredation by carnivores has become an important hurdle in conservation of predators at the top of the food chain. To develop feasible recommendations to minimize this conflict, it is important to learn the circumstances of the predation events and attitudes of people. We assessed the circumstances for livestock depredation by leopards in Ratnagiri district of Maharashtra in India. Records of Maharashtra Forest Department list 621 compensation claims during April 2004 to June 2009. Interviews of 284 affected people were conducted to collect information on the time of attack, location and activity of livestock at the time of attack, people's perception on the initiation and escalation of the depredation problem, compensation programmme and people's solution to the problem. We found that a laid-back attitude while herding, grazing livestock in forest areas was responsible for most of the attacks. Similarly, the locals did not give enough importance to strengthening their livestock enclosures. People perceived that the problem of depredation had started and escalated in recent decades. Although most of them were not happy with the compensation scheme, owing to the meagre amount they got, several affected people showed a positive attitude towards the presence of leopards in their area. Similarly, a fairly good number of interviewed people had started adopting precautionary measures. We concluded that modifications in grazing practices and strengthening of enclosures were the important solutions to the problem of depredation and have suggested several possible approaches for people and the Forest Department.

Key words: leopard, livestock, depredation, grazing, enclosure, conservation, predators, compensation

INTRODUCTION

In the Indian subcontinent, Leopards *Panthera pardus* Linn. 1758 usually, in comparison with other predators, attack more livestock (Rahalkar 2008; Sangay and Vernes 2008). Notwithstanding leopards can also live in human-dominated landscapes with low levels of conflict (Athreya and Belsare 2006). But in the Ratnagiri district of Maharashtra, leopard-attacks on livestock had intensified in 2008 and 2009 (Donikar 2010). However, no cases of purposeful retaliation by livestock owners could be found in the records of the forest department. This could be due to the combined effect of elusiveness and feeding behaviour of leopards that does not allow tracing. This could also be the result of an effective compensation scheme run by the Maharashtra forest department. On the contrary, nearly half of the cases of leopard deaths in the district resulted because of leopards getting snared in wire-nooses placed by farmers for other animals like Wild Pig *Sus scrofa* (Unreported data from Maharashtra forest department).

One of the important aspects in conservation of wild carnivores in human-dominated landscapes is the attitude of the affected people (Rahalkar 2008; Thavarajah 2008). People's approach towards animal husbandry, as well as response to leopard attacks could play a critical role in designing conflict management strategies. These attitudes could be rooted in their traditions, culture, socio-economics and incentive programmes.

We studied the attitudes of people affected with livestock predation by leopards in Ratnagiri district. We used the compensation database of the Maharashtra forest department at Chiplun subdivision for obtaining names and addresses of claimants. We used questionnaire to collect information from a large number of compensation claimants on circumstances of attacks and their response to the situation.

STUDY AREA

Ratnagiri district (15° 36'-18° 05' N; 73° 05'-74° 36' E) is one of the western coastal districts of Maharashtra (Fig. 1). Its geographical area is nearly 8,200 sq. km. Over 85 per cent of land area of the district is hilly, which includes

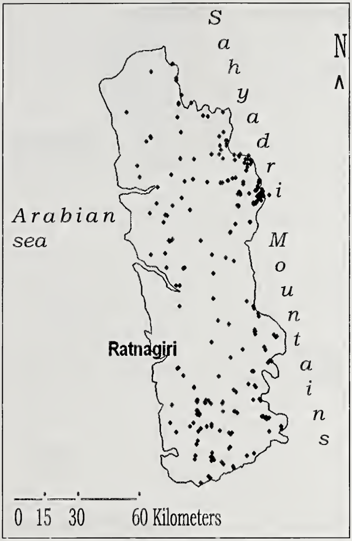

Fig. 1: Locations of leopard attack sites as per information collected from respondents

the Sahyadris (Northern Western Ghats) on its eastern border. Coastal lowlands starkly contrast with the precipitous peaks of the Sahyadris reaching 1,000 m above msl. The climate is tropical with average annual rainfall ranging from 2,500-3,500 mm. The humidity through the year is more than 50 per cent. The summers are hot and winters warm.

This district comprises of a forest Subdivision and three forest ranges. The forest cover is over 51 per cent of the geographical area (FSI 2009). However, most of the forest is under private ownership. Natural vegetation includes moist deciduous and dry deciduous forests, mangrove forest, and grassy plateaus. The landscape is also dominated by rice cultivation and orchards of various horticultural crops, including coconut, areca nut, mango and cashew.

Adjacent to the eastern border of the district are Koyna Wildlife Sanctuary and Chandoli National Park, together proposed as Sahyadri Tiger Reserve. Faunistically, leopard is the largest carnivore here. Several herbivores, like Wild Boar *Sus scrofa*, Spotted Deer *Axis axis*, Nilgai *Boselaphus tragocamelus*, and Gray Langur *Semnopithecus entellus* are reported in the forest department's census. Similarly, Chousingha *Tetracerus quadricornis* has been found to be widely distributed in this district (Patil and Bhave 2009).

Human population of Ratnagiri district as per 2001 census was 15.46 lakhs. Only around 9 per cent of the population was urban; the rest being rural. Much of the rural population practices sustenance livestock husbandry. The total livestock population as per the 17th livestock census conducted in 2003 in terms of productive livestock, i.e., goat, buffalo and cattle was 37,562, 60,220, and 4,77,421 respectively (Department of Animal Husbandry, Government of Maharashtra, unpublished data from website www.ah.adfmaharashtra.in).

METHODS

The information on instances of human-leopard conflict in the district for the period from April 2004 to June 2009 was collected from the forest department records. A questionnaire was prepared to collect additional evidence on leopard attacks from the claimants of compensation. The questionnaire was administered to 284 respondents during July 2009 to May 2010. The information collected included time of attack, location of attack, and activity of the livestock when the attack took place. The respondents were asked the exact time of attack if they or anyone else witnessed it, if not, they were asked to report the tentative time of attack considering relevant aspects of the event. For analysis, time data was segregated into 8 time periods of 3-hr slots to effectively cover a day. They were asked if the attacked livestock was grazing, tied in the open or inside an enclosure at the time of attack. Also information was sought on whether the livestock was attacked in a forest area, farmland, inside a village or at its outskirts.

The respondents were asked to report their views on initiation and escalation of the livestock depredation problem. They were given choices – 2 years back, 5 years back, 10 years back and more than 10 years. They were also asked if leopards were always around in their area. Since these people were claimants of compensation from the forest department for loss of livestock, they were asked if they had received the compensation, and if so, were they satisfied with the amount. They were also asked to report preventive measures taken to avoid depredation of their livestock by leopards. This was an open-ended question bringing in a variety of answers. The responses were categorized into three classes – grazing related, enclosure related and general.

The data was viewed from a descriptive perspective and results presented in terms of proportions and percentages.

Wherever possible, observed frequencies were compared with expected frequencies using chi-square test.

RESULTS AND DISCUSSION

Most of the respondents were farmers (93%, n = 263); others being housewives, people employed in sundry government jobs, etc. Farmers practicing sustenance livestock husbandry were found to be the most commonly affected people.

Circumstances of leopard attacks

More than 60 per cent attacks (n = 174) took place during daytime as against 18 per cent (n = 50) during night. 22 per cent (n = 61) attacks took place during dusk and dawn hours (Note the distribution of the attacks in different time slots in Figs 3 and 4). The results contradict the well-known 'nocturnal hunter' image of the leopard. Jenny and Zuberbuhler (2005) have also reported differential behaviours in savannah leopards and forest leopards. They reported that forest leopards were diurnal and crepuscular hunters, as against nocturnal savannah leopards. Findings in our study match their conclusion as the leopards in the study area exhibited a diurnal and crepuscular tendency of attack in more than 80 per cent cases.

Respondents were asked to report the activity of livestock and location of attack when an attack took place (Fig. 2). Two hundred and thirty-two attacks (81%) took place while the livestock were grazing. The remaining 53 (19%) attacks took place when the animals were either inside an enclosure or tied in the open. Maximum attacks (71%, n = 203) took place in the forest area, followed by 58 (20%) on the outskirts of villages. Data indicates that a significant number of attacks took place while the livestock were grazing in forest area, followed by livestock penned inside enclosures at the outskirts of villages ($\chi^2 = 149.76$, df = 6, $p<0.001$).

Selection of forest as a favourite killing ground is ecologically rooted in the hunting behaviour of a leopard, which is a forest animal. The leopard's hunting success lies in its ability to maintain stealth and stalk its prey. Arivazhagan *et al.* (2007) report that hunting activity of leopards is largely restricted to less disturbed forest areas, which was corroborated by our study. Similarly, Balme *et al.* (2007) reported that leopards hunted significantly less than expected in grassland habitat. Also, they expected that as long as the density of habitat was not hindering catchability of prey, leopards killed their prey in proportion to its availability.

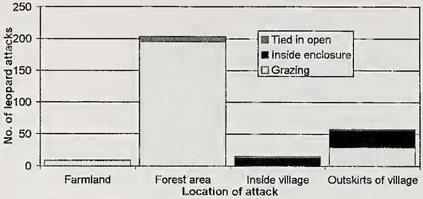

Fig. 2: Distribution of livestock activity with respect to location of leopard attack

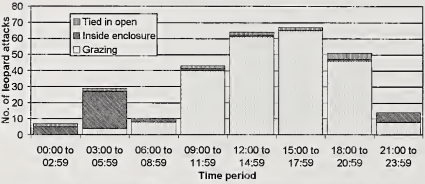

Fig. 3: Distribution of livestock activity with respect to leopard attacks in different time periods of the day

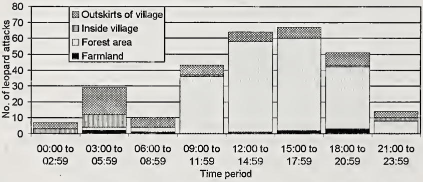

Fig. 4: Distribution of location of leopard attack with respect to different time periods of the day

Another 25 per cent of the attacks took place either at the outskirts or inside a village. At the outskirts of a village, the attacks were irrespective of whether the livestock were grazing or inside an enclosure. Although only five per cent of the attacks were recorded from inside villages, these were invariably of animals inside enclosures.

Patterns in time of attack were more meaningful when considered in combination with activity of livestock (Fig. 3) and location of leopard

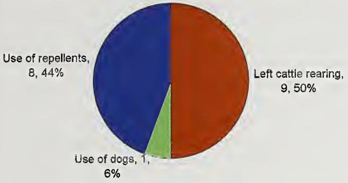

Fig. 5: General steps taken by proactive respondents to prevent livestock depredation by leopard

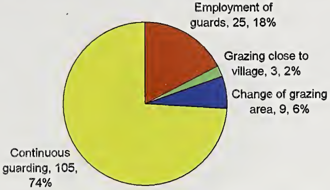

Fig. 6: Steps taken by proactive respondents to prevent leopards from preying on their livestock during grazing

attack (Fig. 4). Maximum daytime attacks (94%, n = 219) took place when the livestock was grazing. Maximum night time attacks (68%, n = 34) took place when the livestock were inside enclosures. There was a high significance associated with these observations ($\chi^2 = 175.01$, df = 14, $p<0.001$). Similarly, maximum attacks (82%, n = 192) during daytime took place in forest area. Maximum attacks during night time (76%, n = 38) took place inside villages or at the outskirts of villages. Here also high significance was associated with these observations ($\chi^2 = 131.01$, df = 21, $p<0.001$)

The results indicate that daytime grazing of livestock in forest area made it vulnerable to leopard attacks. The practice of open grazing in forest area is perhaps crucial for escalating livestock depredation in this region. Wang and McDonald (2006) also reported lax herding, inadequate guarding, and overgrazing as factors for aggravating livestock depredation. In the study area too livestock were left to graze without any serious guarding. Usually children or elderly people took the responsibility of guarding the grazing livestock. These attitudes might have further enhanced the rate of depredation. The study also revealed that at least 12 livestock were killed in the darkest hours of the night while grazing. This was astonishing and exposed the habit of carelessly leaving livestock grazing on their own. Stall-feeding in our study region was observed to be a not-so-favoured practice among the farmers. Therefore, increased levels of guarding and careful herding seem to be the only solution to the problem of depredation during grazing. Guarding of livestock in this region varies in terms of number of guards, age of the guards, and number of guards to livestock. Although we did not explore these issues, further studies would help to outline patterns in these aspects so that appropriate solutions could be recommended. Avoiding forest areas could also be of help.

Most of the attacks inside an enclosure took place during night time. Hence, strengthening of livestock enclosures could be one of the important steps in curtailing leopard attacks on livestock. Ogada *et al.* (2003) presented a very good case of bomas, i.e., cattle enclosures in Kenya. They found that solid bomas performed best over other types made from brushwood, wicker and wire. They also found that the height of the enclosure did not matter much for a leopard. Thus, an enclosure with strong walls and solid roof could effectively reduce predation by leopard.

Peoples' solution

Most individuals had suffered predation of livestock by leopards only once. But 24 individuals had their livestock attacked twice, four individuals thrice and one person on five occasions. Thus, nearly 5 per cent (n = 29) of the affected individuals had suffered repeated attacks on their livestock. Although, 95 per cent people had been affected only once, increase in predation or awareness might have prompted them to take steps to protect their livestock. The respondents were also asked to report these steps.

Nearly 65 per cent (n = 184) respondents reported the steps taken to prevent leopard attacks on their livestock; these respondents were called proactive respondents. The response was grouped into three categories – general response, grazing related response and enclosure related response.

Seventy-seven per cent (n = 142) of the proactive respondents changed their grazing practice, 17 per cent (n = 31) enclosure characteristics, and 10 per cent (n = 18) general aspects of livestock rearing. The sum total does not yield 100 per cent as some proactive respondents took more than one step to secure their livestock.

Among the general steps, 50 per cent respondents abandoned cattle rearing (Fig. 5). 44 per cent created din, i.e., burst crackers, etc. when a leopard approached. Only one respondent began using a dog to guard the livestock. Continuous guarding and employment of guards were the major shifts in grazing practice followed by 92 per cent (n = 130) of the respondents (Fig. 6). Changing grazing area

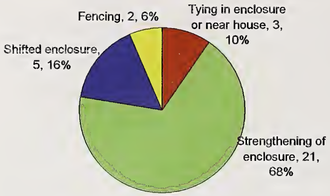

Fig. 7: Steps taken by proactive respondents to prevent leopards from preying on their livestock inside enclosures

and grazing close to villages was followed by a few proactive respondents. Enclosures were strengthened (68 per cent proactive respondents, n = 21) and shifted to a secure place (16 per cent proactive respondents, n = 5) (Fig. 7). Other steps included improvement of fencing and precautions to tie livestock either inside an enclosure or near the house.

A good number of individuals were observed taking precautions to prevent depredation of their livestock. Guarding livestock while grazing was one of the major steps in this direction.

Perceptions about human-leopard conflict

Perceptions of respondents to the status of human-leopard conflict in their surroundings was assessed by posing questions about presence of leopards, time-scale and intensity of depredation problem and their willingness to have leopards around. A large percentage (95%, n = 270) of respondents informed that leopards were always around. It was interesting to learn that of the remaining 14 respondents, 13 belonged to Dapoli range, this highlights the expansion of human-leopard conflict in Dapoli range in recent times.

Similarly, 79 per cent (n = 225) respondents said that the problem of leopard depredation on livestock had started long ago. Relatively fewer respondents informed that the problem started five years ago (8%, n = 22) and 10 years ago (13%, n = 37). Nearly 44 per cent (n = 26) of the respondents who felt that the problem did not start long ago were from Dapoli.

Although a high percentage of respondents felt that the problem had started long ago, only 25 per cent (n = 72) felt that the problem had escalated long ago. A relatively higher percentage (39%, n = 112) felt that the problem had escalated five years ago and 31 per cent (n = 89) felt that the problem had escalated 10 years ago. Only a marginal number of respondents, i.e., 11 felt that the problem had escalated two years ago.

When respondents were asked whether they wanted leopards around either with or without its depredation problem, the response was mixed. It was not surprising that nearly 56 per cent (n = 158) respondents were hostile towards presence of leopards. Close to 44 per cent respondents were, however, positive in their outlook and wanted leopards around, but without the depredation problem. Only two respondents wanted leopards around with the depredation problem. It was a positive sign that a fairly large number of individuals were receptive to the presence of leopards, especially since they had suffered loss of livestock.

Perceptions on Compensation

Even among the respondents, the percentage of claimants that received compensation was high (82%, n = 233). However, the satisfaction level with this compensation was very low. Only about 43 per cent (n = 101) of the claimants who received compensation were happy with it and said that it was adequate. The remaining (57%, n = 132) found it inadequate.

The compensation figures indicate that majority of the claimants had received compensation for loss of livestock. Albeit, the amount received may not be worth the trouble a claimant undertook during the procedure, which may take more than 6 months until actual receipt of money. Although compensation is not a solution to human-wildlife conflict, it is expected to prepare people to accept the presence of predators and certain levels of livestock depredation, which we have already discussed. It was, therefore, not surprising that the Maharashtra forest department had come-up with a fresh compensation scheme in 2010, with considerably enhanced rates of compensation.

CONCLUSIONS

Exploration of circumstantial evidence revealed that lax grazing in forest areas was the common situation at the time of leopard attack on livestock. It could be concluded that people needed to change their attitudes to protect their livestock themselves. People had already started improving the guarding regime while grazing their livestock. Sustaining this approach appears necessary to prevent livestock predation. Although compensation provides temporary relief, it can never match financial benefits had the livestock been alive.

Compensation programme of the forest department was found to be effective in Ratnagiri district, providing benefit to a large proportion of claimants. However, our observations also revealed (unrecorded) that a number of cases of livestock depredation go unreported. A proactive approach on part of the forest department could build faith in people. The forest department could also take up a programme to subsidize strengthening of livestock enclosures. Similarly, it could concentrate on preventive measures in Dapoli range where the problem has just begun, and undertake a curative approach in ranges where the problem of depredation was an established one. The forest department also needs to maintain information on circumstantial facts for further analysis of trends.

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We thank the officials in the subdivision office at Chiplun and range offices at Ratnagiri, Chiplun, and Dapoli for permitting access to their compensation records. We express our gratefulness to all the respondents for their kindness and co-operation. The first author was helped by Miss Jyothi Mandan, and Mr. Punjabrao Shinde while collecting data and they deserve a special mention.

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FRUGIVORY BY BIRDS AND MAMMALS IN SRIHARIKOTA ISLAND, SOUTHERN INDIA

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Fleshy-fruits and their consumers were documented in a coastal tropical dry evergreen forest in southern India from April 2005 to May 2008. Twenty-one species of birds and nine species of mammals were recorded feeding on 56 fleshy-fruit species. The major avian frugivores were Red-whiskered Bulbul *Pycnonotus jocosus* and White-browed Bulbul *Pycnonotus luteolus*. Bonnet Macaque *Macaca radiata*, Golden Jackal *Canis aureus*, Small Indian Civet *Viverricula indica*, Short-nosed Fruit Bat *Cynopterus sphinx* and Indian Flying Fox *Pteropus giganteus* were the major mammalian frugivores.

The frugivore assemblage in Sriharikota is typical of degraded secondary vegetation. Use of fleshy-fruits by birds was limited by seed protection in the form of husk and tough fruit/seed coat and to some extent by fruit colour, whereas mammals used a variety of fleshy-fruits. Green ripe fruits, avoided by birds and most mammals, were chiefly or exclusively eaten by fruit bats.

Figs (*Ficus* species) are an important fleshy-fruit resource for frugivores. The Coppersmith Barbet *Megalaima haemacephala* shows a high degree of dependency on figs. Fruit bats utilized figs almost in all months of the study period. The conservation of fig trees, and other bird and bat attracting flora is vital for the survival of frugivores, which are important components in forest ecosystems, due to their crucial role in seed dispersal and regeneration.

Key words: Frugivory, *Ficus*, Figs, Fruit bats, keystone species, Sriharikota

INTRODUCTION

Many tropical plants produce fleshy fruits which are consumed by a variety of frugivorous birds and mammals to fulfill their nutritional requirements (Snow 1981; Balasubramanian and Bole 1993; Remsen *et al.* 1993; Balasubramanian 1996; Corlett 1998b; Clark *et al.* 2001; Ganesh and Davidar 2001; Bollen *et al.* 2004). Other than seed-eating frugivores, frugivores in general aid in seed dispersal, and also help seeds escape the deleterious effects of seed and seedling predators (Janzen 1970). They also help in the germination success of seeds as the hard seed coat get softened (thereby, breaking the dormancy), as they pass through the gut. Thus, many frugivorous birds and mammals play a crucial role in the regeneration of forest plants. In fact, the spectacular evolutionary success of tropical flowering plants over the past several million years can be attributed to their reliance on animals for pollination and seed dispersal rather than wind (Fleming *et al.* 1987).

Globally, not considering the temperate regions; sites in the neotropics have the richest assemblage of frugivorous birds, while sites in Southeast Asia have the lowest avian frugivore diversity (Fleming *et al.* 1987). In the Indo-Malayan region, birds of at least 41 families include fruit in their diet; 17 of which are highly frugivorous (Corlett 1998b). In southern India, 66 species of birds from 16 families have been documented for frugivory with Columbidae, Pycnonotidae and Muscicapidae representing the most number of species (Balasubramanian and Maheswaran 2003). Among mammals, primates and fruit bats are the chief frugivores in tropical regions (Fleming *et al.* 1987; Corlett 1998b).

Community level studies on frugivory and seed dispersal has brought into focus the importance of fruit characters such as size, colour and nutritional value in fruit selection by birds and mammals (Gautier-Hion *et al.* 1985; Wheelwright 1985; Bollen *et al.* 2004; Kitamura *et al.* 2005), and enabled scientists to identify important fruiting trees or keystone resources (Terborgh 1986; Bleher *et al.* 2003). In India, most of the studies on frugivory have focused on a single animal or plant species (Borges 1993; Kannan and James 1999; Sreekumar and Balakrishnan 2002; Datta and Rawat 2003; Balasubramanian *et al.* 2004; Prasad *et al.* 2004; Mishra and Gupta 2005) with very few community level studies (Balasubramanian and Bole 1993; Balasubramanian 1996; Ganesh and Davidar 2001).

In degraded landscapes, knowledge of the relative attractiveness of native plants to frugivorous birds is useful in planning reafforestation because fruiting trees will attract birds which carry seeds of other species in their guts, thus increasing the diversity of the forest (Corlett 1992). With this background and understanding, a community level study on fruit-frugivore interactions was undertaken in a Tropical Dry Evergreen Forest (TDEF) in Sriharikota Island from April 2005 to May 2008.

The paper chiefly deals with the fleshy-fruit resources of birds and mammals, their physical traits, and the utilization pattern by birds and mammals. It shortlists the major fleshy-fruit species, whose conservation is vital for the survival of frugivores, and the overall health of the forest ecosystem on the Island.

STUDY AREA

The study was undertaken in Sriharikota (13° 45' N; 80° 20' E) lying in the southern Indian states of Andhra Pradesh and Tamil Nadu with an area *c.* 180 sq. km (Fig. 1). It is bounded on the east by the Bay of Bengal and on the west by Pulicat lake. Sriharikota has been connected by road to Sullurpet (18 km) on the mainland since 1970.

Though the Island is affected by both the monsoons, the principal rainfall is mainly from the North-east monsoon. The annual rainfall averages around 1,200 mm. The average humidity varies from 55% in summer to 75% during monsoon. Temperature ranges from 20°C in winter to 40°C during summer. Low-lying areas of Sriharikota get inundated during the North-east monsoon, creating streams and pools. Besides the monsoonal inundation, the wetlands of Sriharikota comprise of lakes (both fresh and brackish), streams (both fresh and brackish), creeks, and natural and man-made freshwater ponds. Cane brakes line most of the waterways. The water table is *c.* 2 to 5 m.

The forest in the Island has been classified as Tropical Dry Evergreen Forest (TDEF) (Champion and Seth 1968). The forest has a long history of disturbance. Forest exploitation goes back to the British era when patches of forest were selectively felled for timber. Subsequently, people from the mainland settled along the margins of the Island, which were earlier inhabited by tribal Yanadis. The settlers cleared areas for cultivation, especially along the western borders of the Island (central and southern parts) with alluvial soil facing Pulicat lake. Some important fruit-bearing and shade trees such as Mango *Mangifera indica*, Neem *Azadirachta indica*, Indian Ash Tree *Lannea coromandelica*, Tamarind *Tamarindus indicus* and Palmyra *Borassus flabellifer* were introduced in village areas. During the early 1970s, the Indian Space Research Organisation (ISRO) took over the Island and set its spaceport. As a result of this long and varied human exploitation, what remains today are patches of secondary forest in various stages of regeneration with isolated old, tall trees that were not felled, especially *Tamarindus indicus*, *Syzygium cumini* and *Sapindus emarginatus*.

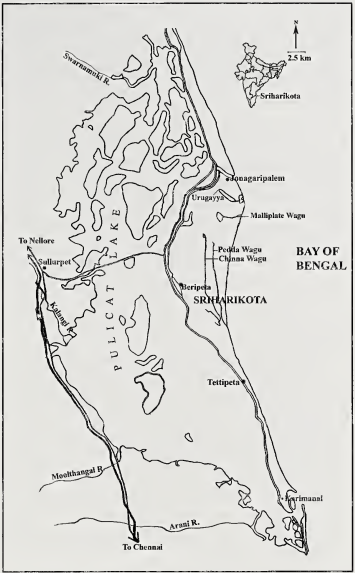

Fig. 1: Sriharikota Island and its adjoining areas

There are broadly five major vegetation types/habitats in the Island:

Tropical Dry Evergreen Forests (TDEF): Found in the central part of the Island, stretching from south of Urugayya lake till around Picheru Gunta, except in sandy tracts or areas under plantations. The tree species include *Syzygium cumini*, *Pterospermum canescens*, *Manilkara hexandra*, *Garcinia spicata*, *Strychnos nux-vomica*, *Pongamia pinnata*, *Tamarindus indicus* and *Cordia dichotoma*. The shrub layer includes *Memecylon umbellatum*, *Glycosmis pentaphylla*, *Eugenia bracteata*, *Grewia rhamnifolia* and *Breynia vitis-idaea*. Climbers such as *Abrus precatorius*, *Asparagus racemosus*, *Cissus vitiginea*, *Jasminum* spp. *Carissa spinarum*, *Olax scandens*, *Coccinia grandis* and *Ziziphus oenoplia* make the forest dense and impenetrable.

Herbs are mainly restricted to the open patches in the forests. Along streams and shallow basins, which are inundated during the monsoon, *Terminalia arjuna*, *Barringtonia acutangula* and *Pongamia pinnata* are dominant, *T. arjuna* occurring in pure stands in some patches. Canebrakes line most of the waterways.

Open Scrub: Open scrub forest is largely present in the sandy tracts, which mostly occur in the northern, eastern and southern fringes of the Island. The ground is sandy and much exposed with a predominance of shrubs like *Gmelina asiatica*, *Diospyros ferrea*, *Securinega leucopyrus*, *Catunaregum spinosa*, *Canthium parviflorum*, *Maytenus emarginatus*, *Dodonea viscosa*, *Capparis* spp., *Carissa spinarum*, *Pavetta indica* and *Atalantia monophylla*. Scattered trees of *Syzygium cumini*, *Sapindus emarginatus*, *Lannea coromandelica*, *Ficus* spp., *Azadirachta indica*, *Albizia amara*, *Walsura trifolia*, *Pamburus missionis* and *Ochna obtusata* occur.

Abandoned Village Forest: The stretch of land situated on a low basin between Kothachenu to Tettipeta, and to a lesser extent around Penubakkam to the former Chengalapalem was cultivated in the past. Ponds were maintained to irrigate the paddy fields in the basin and the other crops at its borders. Now abandoned, these areas have their own characteristic vegetation comprising the regenerating forest of largely *Ficus* spp., *Albizia amara* and *A. lebbeck* amidst coconut, palmyra, neem and tamarind trees. The irrigation ponds have been colonized by canebrakes and *Barringtonia acutangula*.

Eucalyptus Plantation: Eucalyptus plantations are mainly seen from about Urugayya lake to the south of Picheru Gunta. Shrubby elements such as *Memecylon umbellatum*, *Securinega leucopyrus*, and *Catunaregam spinosa* form the undergrowth. An understorey of *Strychnos nux-vomica*, *Garcinia spicata* and *Ochna obtusata* has also come up in some of the more open plantations.

Casuarina Plantation: Casuarina plantations are seen in a narrow belt almost all over the sea coast, starting from east of Chandrasikuppam to Karimanal. Unlike eucalyptus, the casuarina plantations form dense, pure stands with some mixture of native species. Shrubs and trees like *Securinega leucopyrus*, *Azadirachta indica* and *Pavetta indica* form the understorey. *Olax scandens* is a common climber, while *Dendrophthoe falcata* (=*Loranthus longiflorus*) is a common stem parasite on casuarina (Suryanarayana *et al.* 1998).

The flora and fauna of the Island has been well-documented through a number of studies with 445 species of plants of 117 families, 27 species of mammals, 223 species of birds, 12 species of amphibians, 34 species of reptiles, 44 species of fish and 51 species of butterflies recorded (Suryanarayana *et al.* 1989, 1998; Samant and Rao 1996; Rao 1998; Manakadan and Sivakumar 2004a, b; Sivakumar and Manakadan 2004, Sivakumar *et al.* 2004). The mammals in the island include the Bonnet Macaque *Macaca radiata*, Slender Loris *Loris lyddekerianus*, Golden Jackal *Canis aureus*, Rusty-spotted Cat *Prionailurus rubiginosus*, Small Indian Civet *Viverricula indica*, Indian Flying Fox *Pteropus giganteus* and Short-nosed Fruit Bat *Cynopterus sphinx*.

For more details of the island and description of habitats, see Venugopal Rao (1977), Reddy (1981), Reddy (1983), Suryanarayana *et al.* (1998), Rao 1998, and Manakadan and Sivakumar (2004a, b).

METHODS

Fruit-use by Birds

Data on avian visitors to fruiting plants and fruit handling technique was obtained through tree watches (extended observations on fruiting trees) and opportunistic observations (Bollen *et al.* 2004). In tree watches, fruiting plants were observed between 06:00-09:00 hrs from a hide set up 15-20 m away. During this period, for every five minutes, records were kept on the bird and mammal species, and numbers visiting the fruiting tree and their fruit handling techniques. Twenty-one fleshy-fruit species were observed, totalling 242 tree watch hours (TWH). The observation period for each fleshy-fruit species varied depending on crop size, availability of fruiting plants and season. Additional frugivory records were obtained opportunistically during bird census, phenology trips and other field visits comprising 305 frugivory records. We could not quantify the number of fruits removed by frugivores during tree watches due to dense foliage and high visitation rates of birds, which made it difficult to track individual birds. So, only the number of visits was quantified.

Fruit-use by Mammals: Data on fruits utilized by mammals was obtained by collecting and examining faeces from direct feeding observations on fruiting trees (tree watches and opportunistic records) and fruit debris evidence. Faeces of Golden Jackal, Small Indian Civet and Bonnet Macaque were collected fortnightly while walking along 10 phenology trails totalling *c.*10 km. Faeces were also collected by travelling along a 5 km road on a motorbike once a fortnight. We mainly relied on the knowledge of our tribal field assistant, who had good knowledge of the wildlife of the Island, on the identity of the faeces and on animal footprints around the faeces. Faeces that could not be recognized were classified as "unidentified". The seed species and their numbers were recorded separately for each faeces.

Information on fruits utilized by the two fruit bat species in the Island, Short-nosed Fruit Bat and Indian Flying Fox, was collected from examination of fruit debris, i.e., spat-out pulp after extraction of juices (Long and Racey 2007). We could not clearly distinguish between fruit debris of Short-nosed Fruit Bat and the Indian Flying Fox, so a general term 'fruit bats' is used referring to both the species.

For fruits that were intensively used by fruit bats (*Atalantia monophylla, Garcinia spicata, Pamburus missionis* and *Opilia amentacea*), the quantity of fruits eaten was estimated by clearing the ground below the fruiting tree and monitoring these fruit plots (cleared patches) during the entire fruiting period. The fruit debris in the fruit plots was categorized into bat-chewed pellets, partially eaten fruits, seeds, ripe fruits and unripe fruits. In *Atalantia monophylla*, the number of fruits eaten by fruit bats was estimated by dividing the total number of seeds by the average number of seeds (5) per fruit. In the one-seeded *Opilia amentacea*, a seed was equivalent to one fruit. In *Garcinia spicata* and *Pamburus missionis*, a bat-chewed pellet was considered as one fruit. For these two species, the number of seeds was not taken into consideration as these fruits were also eaten by the Bonnet Macaque and Asian Koel *Eudynamys scolopaceus* (only *Pamburus missionis*), with a lot of seeds dropped in the process. This sampling does not take into account fruits carried away from the fruiting tree by fruit bats and those eaten by rodents on the ground. However, it does provide a rough idea of fruit-use by fruit bats and the competition with other frugivores.

Fig-use by Bats: A total of 119 fig trees of 4 species were tagged to estimate fig utilization by fruit bats. The trees were visited fortnightly from September 2006 to May 2008, and the presence/absence of bat-eaten fruits below the fruiting trees was recorded.

Statistical Analysis: To assess for differences in fruit traits used by mammals and birds, G-test was used. To compute G-values for fruit colour, violet was clubbed with black, and orange with yellow. Similarly fruit types other than drupe, berry and achene were clubbed together as one fruit type, and in the case of life forms, small trees and large trees were clubbed together as trees.

RESULTS

Frugivore Assemblage: A total of 21 species of birds and 9 species of mammals were recorded to include fleshy-fruits in their diet. Among birds, 11 species were sighted rarely in the study area or fed on fruits only occasionally and these are not discussed further. The remaining 10 species fall under 7 genera and 7 families. Family Pycnonotidae was represented by 3 species, Corvidae by 2 species and the rest of the families by a single species (Table 1). The major avian frugivores were the Red-whiskered Bulbul *Pycnonotus jocosus* and White-browed Bulbul *P. luteolus*.

Table 1: Avian and mammalian frugivores of Sriharikota

Common Name	Scientific Name	Family	Diet Category	No. of plant species utilised
Birds				
Orange-breasted Green-Pigeon	*Treron bicinctus*	Columbidae	Chiefly frugivorous	7
Rose-ringed Parakeet	*Psittacula krameri*	Psittacidae	Chiefly frugivorous	10
Asian Koel	*Eudynamys scolopaceus*	Cuculidae	Omnivore	23
Coppersmith Barbet	*Megalaima haemacephala*	Capitonidae	Chiefly frugivorous	7
Red-vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	Chiefly frugivorous	16
Red-whiskered Bulbul	*Pycnonotus jocosus*	Pycnonotidae	Chiefly frugivorous	31
White-browed Bulbul	*Pycnonotus luteolus*	Pycnonotidae	Chiefly frugivorous	29
Common Myna	*Acridotheres tristis*	Sturnidae	Omnivore	12
House Crow	*Corvus splendens*	Corvidae	Omnivore	5
Indian Jungle Crow	*Corvus (macrorhynchos) culminatus*	Corvidae	Omnivore	12
Mammals				
Bonnet Macaque	*Macaca radiata*	Cercopithecidae	Chiefly frugivorous	34
Golden Jackal	*Canis aureus*	Canidae	Carnivore	23
Small Indian Civet	*Viverricula indica*	Viverridae	Carnivore	16
Three-striped Palm Squirrel	*Funambulus palmarum*	Sciuridae	Herbivore	17
Fruit bats (Short-nosed Fruit Bat, Indian Flying Fox)	*Cynopterus sphinx, Pteropus giganteus*	Pteropodidae	Chiefly frugivorous	19

The mammals with significant fleshy-fruit intake in their diet were Bonnet Macaque, Golden Jackal, Small Indian Civet, Indian Flying Fox, Short-nosed Fruit Bat and Three-striped Palm Squirrel *Funambulus palmarum* (Table 1). The other species for which frugivory records were obtained occasionally were the Common Mongoose *Herpestes edwardsii*, Spotted Deer *Axis Axis* and Wild Boar *Sus scrofa*.

Fruit-Use: A total of 56 fleshy-fruit species of 33 families were eaten by frugivores. Birds accounted for 38 of these species and mammals 46 species. Ten fruit species were exclusively consumed by birds and 18 exclusively by mammals. The family Moraceae was represented by the highest number of species (5), followed by Rubiaceae (4). Twelve species were climbers, 13 were shrubs, 14 were small trees and 17 were large trees (Appendix 1).

Fruit-use by birds: The Red-whiskered Bulbul and the White-browed Bulbul consumed 34 of the 38 fleshy-fruits eaten by birds and are the major avian frugivores of Sriharikota. The Red-vented Bulbul *P. cafer* was recorded to feed on 16 species and the Asian Koel on 23 species. The Coppersmith Barbet *Megalaima haemacephala* has a narrow diet range, using only 7 of the 38 species, of which 4 were figs; the others were *Lannea coromandelica*, *Syzygium cumini* and *Ziziphus oenoplia*.

Fruit-use by mammals: The Bonnet Macaque was recorded to feed on 34 of the 46 fleshy-fruits eaten by mammals (Table 1). Seventeen species were recorded in 95 droppings (with all figs clubbed as one species), the rest were based only on feeding observations. The bulk of seeds recorded in the droppings were of *Ficus* spp. and *Cordia dichotoma* (Appendix 2). More than 50% of droppings contained plant remains other than seeds, such as leaves, skin of fruits, flowers and twigs. Opportunistic feeding records and faeces analysis indicate that figs are a major food resource for the Bonnet Macaque.

Faeces analysis (n= 473) and direct feeding observation showed that the Golden Jackal feeds on 23 native species and 4 introduced species (*Anacardium occidentale*, *Calamus rotang*, *Morinda tinctoria* and *Guazuma ulmifolia*). The bulk of the fruit diet (judging by the abundance of seeds and frequency of occurrence) was contributed by *Syzygium cumini*, *Phoenix farinifera*, *Memecylon umbellatum*, *Cordia dichotoma* and *Grewia rhamnifolia* (Appendix 2). The number of seeds per scat was relatively high in Golden Jackal (Fig. 2). The Small Indian Civet scats (n=134) contained seeds of 16 species, mostly comprising of species recorded in the Golden Jackal scats.

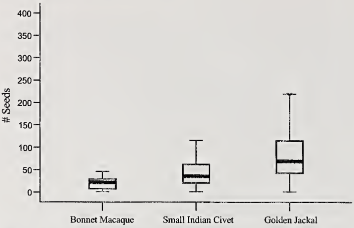

Fig. 2: Box plot showing number of seeds in the mammal droppings

Fruit bats were recorded to feed on 21 species of fleshy-fruits, which included two introduced species (*Polyalthia longifolia* and *Spondias pinnata*). The important fruit resources for fruit bats in Sriharikota are *Atalantia monophylla*, *Garcinia spicata*, *Opilia amentacea*, *Pamburus missionis* and *Syzygium cumini*. Among these, *A. monophylla* and *O. amentacea* were almost exclusively eaten by fruit bats (Table 2). Four of the 5 green fruits used by mammals were consumed chiefly/exclusively by fruit bats. Except for *Garcinia spicata*, none of the fruits had an odour perceivable to humans. Fruit bats were also recorded to feed on the leaves of *Sapindus emarginatus* and *Ficus benghalensis*.

In addition to these five major mammalian frugivores, four more species were recorded to feed on fleshy-fruits. The Three-striped Palm Squirrel used 17 species of fleshy-fruits. Seeds of *Catunaregam spinosa* were recorded in the droppings

Table 2: Quantity of fruits eaten by fruit bats as recorded in fruit plots below fruiting trees

Species	No. of plants monitored	Frequency of monitoring	No. of bat eaten fruits	Partially eaten fruits	Full fruits	
					Ripe	Unripe
Atalantia monophylla	10	Once in 3-5 days	3,664	-	1,810	47
Garcinia spicata	9	Once in 3-5 days	114	211	250	80
Opilia amentacea	7	Daily in the mornings	13,593	226	4,323	1,266
Pamburus missionis	10	Once in 3-5 days	374	700	6,590	112

Note: Refer Methodology and Discussion for details.

of Spotted Deer *Axis axis*; *Syzygium cumini* in Wild Boar dung; and *Phoenix farinifera*, *Grewia rhamnifolia* and *Syzygium cumini* in Common Mongoose scats.

Fruit Traits: Overall, red was the dominant fruit colour, followed by yellow and black (Fig. 3). A high proportion of fruits (71%) (Fig. 4) and seeds (96%) were ≤15 mm in diameter. The largest fruit recorded was *Strychnos nux-vomica* (44 mm) and the smallest was the seedless fruits of *Salvadora persica* (2.4 mm) (Appendix 1). Regarding fruit types, 46% were drupes, 35% were berries, 9% were achenes, 4% were capsules, and the rest comprised of pods, schizocarp and aril (Appendix 1). A comparative assessment of fruits consumed by birds and mammals is given in Table 3. There was no statistically significant difference between birds and mammals with respect to fruit colour (G=4.6, df-5, p>0.05), fruit type (G=0.5, df-3, p>0.05), fruit size (G=4.3, df-2, p>0.05) and life form (G=1.1, df-3, p>0.05).

Bird-Fruits: Red, yellow and black were the major colours displayed by fleshy-fruits eaten by birds (Table 4). Green, brown and violet were displayed only by one species each. Regarding fruit size, 58% of fruits (n=38) ≤ 10 mm in diameter and 84% ≤ 15 mm. Seed diameter ranged from 1.4 mm in *Catunaregam malabarica* to 10.9 mm in *Canthium parviflorum* (excluding very small seeds). Slightly more than 50% of fruits were single-seeded. Large-sized fruits, such as *Capparis brevispina*, *Coccinia grandis*, *Lepisanthes tetraphylla* and *Ficus benghalensis* were multi-seeded (more than 2 seeds/fruit). Two fruit species, *Alangium salvifolium* (stone) and *Casaeria esculenta* (aril) had protection for seeds.

Mammal-Fruits: Among fruits used by mammals, red was the dominant fruit colour displayed by 37% of the species, followed by yellow (20%), and black (15%). Brown was displayed by 3 species (2 more than birds) and green by 5 species (4 more than birds) (Table 4). Nearly 39% of fruits ≤ 10 mm in diameter and 63% ≤ 15 mm (n = 46). Mean fruit size ranged from 4.6 mm to 44 mm. Mean seed size ranged from 1.4 mm (*Catunaregam malabarica*) to 29.5 mm (*Calophyllum inophylum*). When fruits exclusively eaten by mammals were considered (n=14, excluding *Borassus flabellifer* and some fruits showing bird-fruit characters), the mean fruit size ranged from 10.2 mm (*Cassine glauca*) to 44 mm (*Strychnos nux-vomica*). 54% of fruits were single-seeded. Eleven species (25%) had protection for seeds (nine more than birds).

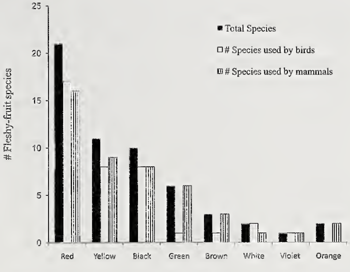

Fig. 3: Fruit colour spectra of bird (n=380) and mammal (n=46) fleshy-fruits

Table 3: A comparative analysis of fleshy-fruits eaten by birds and mammals

Fruit Traits	Birds	Mammals
No. of fruit species used	38	46
Major fruit colours	Red, Yellow, Black	Red, Yellow, Black
No. of species with green coloured fruits	1 (*Ficus amplissma*)	5
Dominant fruit type	Drupe, berry	Drupe, berry
Largest fruit eaten	*Ficus racemosa* (27.8 mm)	*Strychnos nux-vomica* (44 mm)
Largest fruit ingested whole	*Syzygium cumini* (14.7 mm)	*Phoenix sylvestris* (28 mm)
Smallest fruit eaten	*Salvadora persica* Seedless (2.4 mm)	*Ehretia pubescence* (4.6 mm)
% of fruits ≤ 10 mm diameter	58% (n=38)	39% (n=46)
% of fruits with seed protection	5% (n=38)	24% (n=46)

Bird visitation rates to fruiting trees: Tree watches on fruiting trees indicate that some fleshy-fruits attract more number of birds than others (Table 5). The top five species with the highest number of visits were *Ficus amplissima* (91 visits/hr), seedless fruits of *Salvadora persica* (47 visits/hr),

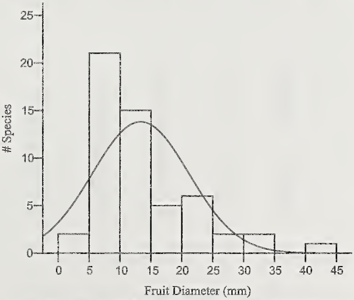

Fig. 4: Frequency distribution of mean diameter of fruits (n=54)

Table 4: Physical traits of fruits consumed by birds and mammals

Taxon	Fruit Colour							
	Black	Red	Yellow	Green	Brown	White	Violet	Orange
Birds	7	18	8	1	1	2	1	0
Mammals	7	17	9	6	3	1	1	2
	Fruit Type							
	Berry	Drupe	Achene	Capsule	Pod	Schizocarp	Aril	
Birds	13	16	5	2	0	0	1	
Mammals	17	22	4	1	1	1	0	
	Fruit Size							
	Large	Medium	Small					
Birds	7	25	6					
Mammals	17	26	3					
	Habit							
	Large Tree	Small Tree	Shrub	Climber				
Birds	10	11	9	8				
Mammals	16	11	8	11				

Note: The 'Fruit Type' under birds does not add to 38 as one species was unidentified

Lannea coromandelica (30 visits/hr), *Walsura trifolia* (28 visits/hr), *Ficus microcarpa* and *Cordia dichotoma* (18 visits/hr). The Red-whiskered Bulbul was the most frequently observed bird species in almost all fruiting trees, except in *Hugonia mystax*, *Lannea coromandelica* and *Securinega leucopyrus* (Common Myna was the frequent visitor for these species) and in *Eugenia bracteata* (Asian Koel was the common visitor for this species) (Figs 5a,b).

Fruit-handling Behaviour

Birds: The majority of fruits (71%, n=38) were swallowed whole by all the bird species. Large fruits like *Pamburus missionis* and *Ficus racemosa* were eaten in bits. In *Azadirachta indica*, *Lannea coromandelica*, *Olax scandens*, *Salacia chinensis* and *Walsura trifolia*, the fruit coat was removed and the seed was swallowed. In *Lepisanthes tetraphylla* (20.1 mm with 3 seeds), the fruit was opened by pecking and the juicy pulp consumed along with the seed. The Rose-ringed Parakeet is a seed-eater or seed-predator or seed dropper (drops the seed below the parent tree, thus not aiding dispersal). While feeding on *A. indica*, it crushed the seeds and ate it in pieces. Its handling of small seeds of *Securinega leucopyrus* and *Coccinia grandis* is unclear. While feeding on fruits of *Alangium salvifolium*, it dropped large amount of seeds under the fruiting tree.

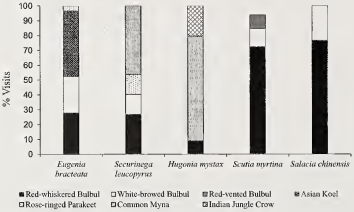

Fig. 5a: Frequency of visits by avian frugivores to some species of fleshy-fruit shrubs and climbers

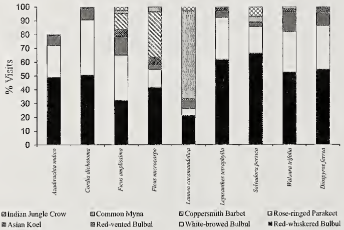

Fig. 5b: Frequency of visits by avian frugivores to some species of fleshy-fruit trees

Mammals: The presence of both fruit-coat and seeds in Golden Jackal and Small Indian Civet scats suggests that they eat the fruits whole. The Bonnet Macaque handled the fruit in three ways: swallowing the seeds whole (aiding in dispersal), crushing and eating the seeds (seed predation) and dropping the seeds either under or away from the parent tree. The Three-striped Palm Squirrel is both a seed dropper and predator. Seeds of *Cordia dichotoma* (tree watch hours = 30) and *Ziziphus oenoplia* (opportunistic observation, n=3) were dropped; *S. cumini* and *Z. mauritiana* (fruit debris data) were predated. From the only direct record of feeding habits in the Short-nosed Fruit Bat (while feeding on *Atalantia monophylla* fruits), it was observed that they ingested only the fruit juice after chewing the pulp and the seeds were dropped.

Fig-Use

Birds: All the avian frugivores were recorded feeding on figs (*Ficus*). Out of the 305 opportunistic frugivory records, 128 were on figs. *F. amplissima* recorded the highest number of avian frugivores (398 visits in 4½ hours) during the tree watches. The highest number of opportunistic records were also made on *Ficus amplissima* (48), followed by *Ficus benghalensis* (44) and *Ficus microcarpa* (31). Frugivory records on *Ficus racemosa* and *Ficus religiosa* were less, as the former is primarily used by mammals and the latter is very rare in the island.

The Coppersmith Barbet was chiefly a fig-eater, 90% of its frugivory records (n = 30) were on three *Ficus* spp. Among the 21 species subjected to tree watches, the Coppersmith Barbet was recorded only on *F. amplissima* and *F. microcarpa*. The Orange-breasted Green-Pigeon *Treron bicinctus* also chiefly feeds on figs. Six out of the 10 frugivory records for this species were on fig fruits (Table 6), including the sighting of 31 birds feeding on a *F. amplissima* tree. Totally, 132 bulbuls were recorded feeding on figs on 58 occasions. Out of the 58 feeding records, the Red-whiskered Bulbul was sighted on 37 occasions.

Mammals: Among mammals, fruit bats used figs frequently. Figs produced ripe fruits almost throughout the study period and fruit debris evidence indicate that fruit bats utilized figs in 19 of the 21 months of study (Fig. 6). The highest number of trees utilized in any given month was 17 (14%, n= 119 trees) in February 2008. The Bonnet Macaque and Three-striped Palm Squirrel also fed significantly on figs (Table 6). The highest number of opportunistic records for both these species was on fig trees, and fig seeds were recorded in 14% of Macaque faeces.

Table 5: Number of visits made by birds to various fleshy-fruit species

Fleshy-fruit Species	Tree Watch Hours	Total Visits /hr								Grand Total
		RWB	WBB	RVB	AK	RRP	CB	CM	IJC	
Ficus amplissima	4.35	29.4	30.1	12.2	4.8	-	10.6	2.1	2.3	91.5
Salvadora persica (seedless)	17	31.6	10.4	0.7	0.4	-	-	2.0	2.4	47.5
Lannea coromandelica	30	6.3	1.6	1.3	-	-	-	18.9	1.6	29.6
Walsura trifolia	6	14.7	8.2	4.0	0.7	-	-	0.3	-	27.8
Salvadora persica (seeded)	16	13.4	2.6	1.3	-	-	-	0.6	2.4	20.3
Cordia dichotoma	30	9.3	7.4	1.5	0.2	-	-	-	-	18.4
Ficus microcarpa	3	7.7	2.3	0.7	1.0	-	6.0	0.7	-	18.3
Hugonia mystax	6	0.7	-	-	-	-	-	5.2	1.5	17.3
Scutia myrtina	6	11.8	2.0	1.5	-	-	-	-	-	15.3
Eugenia bracteata	6	2.8	2.5	-	4.5	0.3	-	-	-	10.2
Lepisanthes tetraphylla	30	5.8	2.8	0.5	0.2	-	-	-	-	9.4
Diospyros ferrea	5.3	4.2	2.3	1.3	0.4	0.2	-	-	-	8.3
Azadirachta indica	16	4.0	1.9	0.6	0.1	-	-	0.5	1.1	8.1
Alangium salvifolium	3	-	-	-	-	1.7	-	-	-	1.7
Securinega leucopyrus	16	3.9	0.9	0.4	-	-	-	1.5	-	6.7
Salacia chinensis	16	2.1	0.6	-	-	-	-	-	-	2.7
Ehretia pubescence	8	-	0.8	-	0.9	-	-	-	-	1.6
Syzygium cumini	4	1.0	0.3	-	-	-	-	-	-	1.3
Ochna obtusata	9	0.7	0.1	-	0.1	-	-	-	-	0.9
Memecylon umbellatum	3	0.3	-	-	-	-	-	-	-	0.3
Olax scandens	3.5	-	-	-	-	-	-	-	-	0.0
Pachygone ovata	4	-	-	-	-	-	-	-	-	0.0

RWB - Red-whiskered Bulbul, WBB - White-browed Bulbul, RVB - Red-vented Bulbul, RRP - Rose-ringed Parakeet, AK - Asian Koel, CB - Coppersmith Barbet, CM - Common Myna, IJC - Indian Jungle Crow.

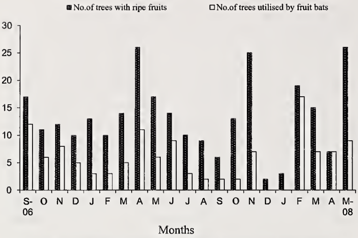

Fig. 6: Utilisation pattern of fig trees (n=119) by fruit bats from September 2006-May 2008

DISCUSSION

Avian Frugivore Assemblage

The avian frugivore assemblage in Sriharikota is typical of open degraded secondary forest associated with human presence. The major avian frugivores were the Red-whiskered and White-browed Bulbuls. Bulbuls are the most important frugivores in anthropogenic open habitats in the Oriental Region (Corlett 1998a, b); e.g., Red-whiskered and Light-vented *Pycnonotus sinensis* bulbuls in a Hong Kong shrub land (Corlett 1998a), and Red-whiskered and Red-vented Bulbuls in many Pacific Ocean islands and in North America where they have colonized (Carleton and Owre 1975; Freifeld 1999). Next to bulbuls, the major avian frugivore in Sriharikota was the Asian Koel. While most cuckoos are carnivorous, the Asian Koel includes large quantities of fruit in its diet (Ali 2002). The Asian Koel occurs from the Indian subcontinent and Southeast Asia through Indonesia to New Guinea and northern Australia (Rasmussen and Anderton 2005). The Rose-ringed Parakeet is another common frugivore encountered in Sriharikota. It is a widespread resident in India and is also found in Africa, Arabia and in the east up to Myanmar. Besides a frugivore, it is a seed predator and causes immense damage to agricultural crops (Rasmussen and Anderton 2005).

Table 6: Opportunistic records of frugivores feeding on fig and non-fig species

Frugivores	Figs	Non-figs
Red-whiskered Bulbul	37	61
White-browed Bulbul	15	32
Red-vented Bulbul	6	10
Asian Koel	13	20
Rose-ringed Parakeet	1	15
Coppersmith Barbet	27	3
Orange-breasted Green-Pigeon	6	4
Common Myna	11	17
Indian Jungle Crow	11	16
Bonnet Macaque	19	16
Three-striped Palm Squirrel	25	17

In open country and human dominated landscapes, members of the family Corvidae and Sturnidae are important frugivores. In such areas, they are often amongst the largest birds, and thus, even these less frugivorous species may be significant as dispersers of fruits and seeds that are too large for smaller frugivores (Corlett 1998b). In Sriharikota, these are represented by the Indian Jungle Crow, House Crow and Common Myna. They are major frugivores and important seed dispersing agents in abandoned village forest and may aid in rapid regeneration of native vegetation.

There are two specialist fig-eaters in Sriharikota, the Coppersmith Barbet and Orange-breasted Green Pigeon. Barbets are among the most highly frugivorous birds in the Indo-Malayan region and several species feed largely on figs for which they are the major dispersal agents (Corlett 1998b). In Sriharikota, the Coppersmith Barbet is rare in TDEF, but is occasionally seen in abandoned village forest where fig trees are abundant (David *et al.* 2008). Members of the genus *Treron* (green-pigeons) are known to be voracious fig feeders and pigeons in general form one of the principle groups of fig-eating birds in Southeast Asian forests (Lambert 1989a). The Orange-breasted Green-Pigeon is a sporadic visitor to the Island from the nearby hills of the Eastern Ghats.

When compared with the avian frugivores of Point Calimere Wildlife Sanctuary (Balasubramanian 1996), a TDEF site 450 km south of Sriharikota, some differences and similarities in the avian frugivore assemblages emerge. There are three species of bulbuls in Sriharikota, *contra* two in Point Calimere. The Red-whiskered bulbul is absent in Point Calimere. The Coppersmith Barbet was also not recorded in Point Calimere (probably due to paucity of figs), but was recorded in Vedaranyam, 11 km to its north, and in adjoining small town and villages, which have fig trees along roads and in temples (Ranjit Manakadan pers. obs). The Rosy Starling *Sturnus roseus* is a regular winter visitor to Point Calimere, but was recorded only occasionally in the southern parts of Sriharikota, where sampling was not done due to difficult logistics. On one occasion, it was observed feeding on *Phoenix farinifera* fruits in April (Manakadan and Sivakumar 2004a), probably on the return from their wintering grounds further south. The Grey-headed Starling *Sturnia malabarica*, a minor frugivore in Point Calimere, has not been recorded in Sriharikota. The Brahminy Starling S*turnus pagodarum* and Orange-breasted Green-Pigeon are seasonal migrants to Point Calimere and Sriharikota.

Mammalian Frugivore Assemblage

The mammalian frugivore assemblage in Sriharikota is very similar to Point Calimere. It comprises of 2 species that are both arboreal and terrestrial (Bonnet Macaque and Three-striped Palm Squirrel), 2 terrestrial species (Golden Jackal and Small Indian Civet) and 2 volant species (Short-nosed Fruit Bat and Indian Flying Fox). The Bonnet Macaque can live in tiny forest patches, use young secondary forest, cross open ground and eat a wide variety of foods (Corlett 1998b). The Golden Jackal is an opportunistic feeder which eats significant amounts of fallen fruit, as reported from studies in Bangladesh, India and Pakistan (Corlett 1998b). The Small Indian Civet is tolerant of human intrusion as long as they are not hunted and appear to thrive in degraded landscapes (Corlett 1998b). The two species of fruit bats recorded in Sriharikota, the Short-nosed fruit bat and Indian Flying Fox, are common and widespread in India (Bates and Harrison 1997) and are the most studied species with regard to frugivory in India and in other regions (Balasubramanian and Bole 1993; Bhat 1994; Elangovan *et al.* 1999; Singaravelan and Marimuthu 2006; Tang *et al.* 2008).

Fruit Traits

Most of the studies across the world associate bird-fruits with black and red colour, small fruit size and without any protection for seeds, while mammals feed on a variety of fruits irrespective of colour, size and texture (Janson 1983; Gautier Hion *et al.* 1985; Corlett 1996; Balasubramanian and Maheswaran 2003; Bollen *et al.* 2004). The traits of bird and mammal fruits of sriharikota are discussed below.

Bird-Fruits

As for fruit colour most of the bird-fruits in Sriharikota display red, black and yellow colour. Does this mean birds avoid other fruit colours? *Walsura trifolia*, a brown fruit was also consumed by birds. *Ficus amplissima*, a green coloured fruit, was fed on by all bird species and opportunistic records on green colour were more than black. Birds are also known to feed on unripe fruits, which are mostly green (Bhat and Kumar 2001). This suggests birds do also eat green and brown fruits, usually associated with mammal-fruits. However, it must be noted that fruits that were small, without protection, but displaying green colour (*Cassine glauca* and *Opilia amentacea*) were still not eaten by birds. The reasons are not yet clear. Green may signal unpalatability or enhance crypsis (Snow 1971). However, Knight and Siegfried (1983) postulated that greenness could be a consequence of genetic pleiotropy with no significant cryptic or advertising function, suggesting that the association of red and black colour fruits with avian frugivores may simply be a reflection of the higher occurrence of fleshy-fruit species with these colours, rather than preference. It would be interesting to test if green and other non bird-fruit colours are avoided in a natural environment if these colours are predominant.

Secondly, bird-fruits are small. This is true in Sriharikota as 58% of fruits (n=38) $\leq$ 10 mm in diameter and 84% $\leq$ 15 mm. However, large sized fruits were also sometimes used by small birds such as bulbuls. Out of the 38 fleshy-fruit species, 6 were larger than the gape width of bulbuls, they were all eaten, but in bits. Birds will be able to exploit large-sized fruits if they are soft.

The bird-fruits in Sriharikota also do not have thick husk or a hard fruit/seed. Only 1 fruit (*Alangium salvifolium*) had a hard seed coat. The pulp of this fruit was consumed by the Rose-ringed Parakeet and the seeds were mostly dropped. Seed protection in the form of a thick husk, or a tough fruit/seed coat is the main factor preventing birds from feeding on some fleshy-fruits. For example, fruits of *Atalantia monophylla* (tough fruit coat), *Mimusops elengi* and *Phoenix sylvestris* (thick husk) were not used by birds in Sriharikota.

Mammal-Fruits

Mammals, unlike birds, have hands and teeth to hold and crush fruits, and hence, feed on a variety of fruits irrespective of colour, size or seed protection. Hence, the number of fleshy-fruit species used by mammals is more than birds. The single fruit trait that could be solely associated with mammals is seed protection (thick husk or tough fruit/seed coat). Out of the 18 species used exclusively by mammals, 11 had seed protection in the form of husk or a tough fruit coat.

Four species of mammal-fruits in Sriharikota are green (*Atalantia monophylla*, *Cassine glauca*, *Opilia amentacea* and *Calophyllum inophyllum*). These were exclusively used by fruit bats and formed 21% (n=19) of the total fruit species used by fruit bats. In a study in Malaysia and Singapore, about 50% of bat-fruits were found to be green in colour, matching the surrounding foliage (Hodgekison and Balding 2003; Boon and Corlett 1989). The majority of fig fruits used by neotropical Phyllostomid bats were also green (Kalko *et al.* 1996). A high proportion of green fruits in the diet of fruit bats could be because green ripe fruits go undetected by birds, as birds associate such fruits with unripeness and/or since green fruits are difficult to spot against the green foliage, and thus, this unharvested fruit resource becomes available to fruit bats. However, birds, as discussed earlier, have colour vision and are also known to feed on some species of green fruits. Flying foxes have no colour vision and therefore olfaction could play a key role in location of ripe fruits (Kalko *et al.* 1996). Except for *Garcinia spicata*, none of the other fruits produced a strong odour (detectable by humans). Hodgekison and Balding (2003) also reported that none of the fruits used by fruit bats produced a strong odour. Conversely, most of the figs used by neotropical Phyllostomid bats produced odour and they used odour as the primary cue to detect figs (Kalko *et al.* 1996).

Fruit-Use

Fruit use by birds: The Red-whiskered Bulbul and White-browed Bulbul consumed more species of fleshy-fruits than other birds. These two species are the most abundant and widespread of birds in Sriharikota (David *et al.* 2008), and hence, they were able to exploit fruit resources available in all the habitats. Open area preferring species like Red-vented Bulbul, Indian Jungle Crow and Common Myna did not exploit fruit resources available in the dense forest such as *Canthium dicoccum*, *Ehretia pubescens* and *Cordia dichotoma*, and thus fed on less number of fleshy-fruit species. The number of fleshy-fruit species eaten by the Asian Koel was less than the bulbuls, though they have a larger gape size. This is probably because they are encountered only occasionally in the Island, mainly during winter (David *et al.* 2008), and it is a secretive species with inconspicuous feeding habits (Corlett and Ping 1995). The Asian Koel because of its large gape size (17.5 mm: source, Balasubramanian 1996) is able to swallow large fruits such as *S. cumini*. In Hong Kong, three large fruits (*Arenga engleri*, *Livistona chinensis* and *Syzygium cumini*) were recorded to be swallowed whole only by the Asian Koel (Corlett and Ping 1995).

Fruit use by mammals: The Bonnet Macaque ate more fleshy-fruit species (34) than the other major mammalian frugivores. Fruits are documented to form a major portion of the diet of the Bonnet Macaque (Ali 1986; Krishnamani 1994; Kuruvilla 1980). Macaques in general, eat anything edible, ripe or unripe, also seeds and leaves, soft or hard skinned fruits, and contribute both to dispersal and predation (Pijl 1982). In Sriharikota, the low number of seeds in droppings, and record of fruit skins without seeds indicate that they either drop seeds or eat them more than swallowing and defecating them intact. Moreover, the high percentage of occurrence of leaves in Macaque droppings points to general deficiency of fleshy-fruit availability.

The Golden Jackal and Small Indian Civet are recorded to include fruits in their diet throughout their range (Corlett 1998b; Jhala and Moehlman 2004). Studies on jackal and civet diet indicate that they prefer insects, rodents, lizards and birds, and fruits form part of their diet whenever they become seasonally available (Rabinowitz 1991; Chuang and Lee 1997; Jhala and Moehlman 2004). Similarly, in Sriharikota, in addition to fruits, remains of rodents, birds and insects were recorded in the scats of Golden Jackal and Small Indian Civet. The Jackal used nearly 50% of fleshy-fruit species for which there is a record of frugivory. Along with the Civet, it was an important disperser of *Syzygium cumini* and *Memecylon umellatum*. They are also the major dispersers for *Calamus rotang*, an introduced species that has attained invasive proportions in Sriharikota. The frequency of occurrence of seeds in scats of these species reflected the abundance of the fleshy-fruit plants, their seasonality and fruiting intensity (David *et al.* 2008).

Fruit bats were recorded to feed on 19 fleshy-fruit species. The fleshy-fruits used by fruit bats could be an underestimate as we relied only on fruit debris and not systematic tree watches. In Point Calimere, Balasubramanian and Bole (1993) recorded fruit bats to feed on 35 fleshy-fruit species, including shrubs and climbers that also occur in Sriharikota. Fruits that are green when ripe are chiefly or exclusively eaten by fruit bats. Among the 4 species intensively used by fruit bats, *Atalantia monophylla* and *Opilia amentacea* appear to be chiefly or exclusively used by fruit bats. The low number of partially eaten fruits of *Opilia amentacea*, the absence of partially eaten fruits of *Atalantia monophylla* and the high number of bat-eaten fruits of these two species indicate that other frugivores did not feed on these two fruit resources. These fruit species are green when ripe and they remain attached strongly to the plant. In contrast, the two other major bat-fruits, *Garcinia spicata*, and *Pamburus missionis* are used by the Bonnet Macaque and Asian Koel. These fruits are delicate and fall off easily, and hence, more partially eaten and fallen ripe fruits were recorded in plots below these two tree species.

Overall, the number of fleshy-fruit species consumed by avian and mammalian frugivores could be higher than recorded. Records of frugivory for some fruits could not be obtained because of rarity (e.g. *Toddalia asiatica*) or due to very poor fruiting (e.g., *Flacourtia indica* and *Carissa spinarum*).

Importance of Figs for Frugivores

In some tropical and subtropical forests, figs (*Ficus*) are acknowledged to be keystone resources for frugivores (Terborgh 1986; Lambert and Marshall 1991; Bleher *et al.* 2003). The features that make figs keystone resources are their ability to support large number of avian and mammalian frugivores, large crop size and fruiting throughout the year (asynchronous fruiting pattern), thus sustaining frugivores through periods of fruit scarcity (Lambert and Marshall 1991).

In Sriharikota, three species of figs, *Ficus amplissima*, *F. benghalensis* and *F. microcarpa*, are common in abandoned village forest (*F. racemosa* and *F. religiosa* are rare). Some fig trees are also found within TDEF. Together, figs fruited almost throughout the year and all the avian frugivores were recorded feeding on fig fruits. However, the importance of figs to frugivores varies. The Coppersmith Barbet feeds intensively on fig fruits (27/30 records were on figs). They track fruiting fig trees throughout the Island and were recorded wherever fig trees were in fruit, even among dense forest patches. In Kuala Lompat (Malaysia), a radio-tagged Yellow-crowned Barbet *Megalaima henricii*, a fig specialist, regularly flew over 700 m from its roost site to feed on fruiting *F. binnendijkii* (Lambert 1989b). In general, barbets are amongst the most frequently observed fig-eaters in Asia and they show a certain degree of dietary specialization towards figs (Shahnahan *et al.* 2001). In Sriharikota, the Coppersmith Barbet was recorded to feed only on three other fleshy-fruit species, but only rarely. Intensive use of fig fruits and a narrow range of non-fig diet confirm figs as keystone resource for the species. Figs are also an important resource for the visiting Orange-breasted Green Pigeon as they are known to be largely voracious fig-eaters (Lambert 1989a).

Tree watches and opportunistic records indicate that bulbuls also consume considerable amounts of fig fruits. Some important fleshy-fruit resources for the bulbuls (*Salvadora persica*, *Lepisanthes tetraphylla* and *Cordia dichotoma*) show unpredictable fruiting patterns and are not reliable (David *et al.* 2008). Hence, figs with their year round fruiting pattern could be a critical fruit resource for bulbuls. Pycnonotidae members are one of the frequently observed bird groups on fruiting fig trees in Asia and Africa (Lambert 1989b; Shahnahan *et al.* 2001). Bulbuls have been recorded to feed on 63 *Ficus* species, and in terms of fig seed dispersal, are probably the most important of the smaller frugivores (Shahnahan *et al.* 2001). Among the three species of bulbuls, the highly mobile Red-whiskered Bulbul is at a distinct advantage. They can fly extensively in search of fruiting fig trees, which are mostly confined to the abandoned village forest. On the contrary, the White-browed Bulbul with its shy nature, sulking behaviour and poor flight will not be able to track fig trees like the Red-whiskered Bulbul and has to rely on the few fig trees within TDEF (its preferred habitat). The Red-vented Bulbul is abundant in open scrub and abandoned village forest (David *et al.* 2008), and so has easy access to fig trees.

Among mammals, figs were found to be important for the Bonnet Macaque and fruit bats. Field observations and faecal dropping analysis revealed that fig fruits are a major component in the diet of the Bonnet Macaque as reported in other studies (Ali 1986; Krishnamani 1994). More than 50% of feeding records on Bonnet Macaque were on fig fruits, and figs appeared in many Macaque droppings compared to other fruits. However, Bonnet Macaques are very catholic in their diet and include a variety of fruit and non-fruit resources (Kuruvilla 1980; Ali 1986; Krishnamani 1994), hence figs may not be a keystone resource for them. Additionally, fig-eating species with territorial lifestyles (as the Bonnet Macaque) may vary in their dependence on figs (Borges 1993).

As fruit bats are obligate frugivores, the availability of figs would be especially important for them. Pteropodidae members are the major consumers of figs in the tropics (Shahnahan *et al.* 2001). In the neotropics, figs constitute the dominant portion in the diet of Phyllostomid bats (Kalko *et al.* 1996). In Sriharikota, figs are very important in the diet of fruit bats as they consumed fig fruits in 19 of the 21 months of study. Secondly, non-fig fruits preferred by fruit bats are mainly available only from June-October and two: *Opilia amentacea* and *Pamburus missionis* are not common in the island (David *et al.* 2008). Other important fleshy fruit resources show unpredictable fruiting patterns. Therefore, the year round availability of fig fruits is crucial to ensure a continuous food supply for fruit bats, and hence, figs can be regarded as a keystone resource for fruit bats in Sriharikota. Figs as a key fruit resource have also been reported for *Pteropus* sp. from the Philippines and Australia (Eby 1998; Stier and Mildenstein 2005) and for Lesser Dog-faced Fruit Bat *Cynopterus brachyotis* from Malaysia (Tan *et al.* 1998).

Thus, figs appear to be an important food resource for both avian and mammalian frugivores, and may be a keystone resource for some species. The loss or decline of fig trees could lead to decline in population of some species of frugivorous birds. Primary fig-eaters, like Coppersmith Barbet may become (locally) extinct and the Orange-breasted Green-Pigeon could stop visiting the Island. This prediction finds support in the findings in a subtropical South African forest where the destruction of *Ficus sycomorus* trees in Umfolozi Nature Reserve after a cyclone in 1984 led to local elimination of some frugivores (Bleher *et al.* 2003). Based on this, they hypothesized that removal of another *Ficus* species, *F. thonningii* in the Oribi Gorge Nature Reserve could drastically influence the frugivore community and hence figs must be considered as a keystone resource.

RECOMMENDATIONS

The findings of this study revealed that the abandoned village forest is an important habitat for avian and mammalian frugivores primarily due to the abundance of fig trees. Hence, even though the abandoned village forest is not a Tropical Dry Evergreen Forest, we suggest that these areas should be given low priority for land acquisition plans for the expansion of the spaceport. Where acquisition is unavoidable, possibilities of avoiding cutting of *Ficus* trees should be explored.

Salvadora persica trees, which are very attractive to avian frugivores, should also be protected. This species occurs only in saline water basins close to Pulicat lake around the former villages of Penubakkam and Beripeta. Within the TDEF, we recommend protection for *Lepisanthes tetraphylla*, *Ehretia pubescens* and *Canthium dicoccum*. These trees occur in low densities. The juicy fruits of *Lepisanthes tetraphylla* are important for birds and bats in summer, while *Ehretia pubescens* and *Canthium dicoccum* are important fruit resources during the north-east monsoon and winter. Other plants of importance for frugivores are *Azadirachta indica*, *Cordia dichotoma* and *Lannea coromandelica* for birds, and *Atalantia monophylla*, *Garcinia spicata* and *Opilia amentacea* for fruit bats.

In addition to these important fleshy-fruit species, visually attractive species such *Breynia vitis-idaea*, *Casaeria esculenta*, *Cansjeera rheedei*, *Pavetta indica* and *Phoenix farinifera* can be grown in gardens and residential facilities of the SDSC-SHAR in Sriharikota and Sullurpet. *Salvadora persica* and *Lannea coromandelica* can be planted along road margins from Attakanithippa to Sriharikota, Pernadu and Veenadu. This recommendation is based on observations of existing trees along the road which are doing well compared to other species that wither due to the impact of salt and strong winds. *Lannea coromandelica* can also be grown and planted along the road from Sullurpet to the SDSC-SHAR residential area (Pulicat Nagar).

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Appendix 1: Fleshy-fruit species and their fruit-traits

Species	Fruit Colour	Fruit type	Mean Fruit Size (mm)	Mean Seed Size (mm)	No. of seeds	Seed Protection	Consumer
Large Trees							
Alangium salvifolium	Red	Berry	16.0	10.0	1	Yes	BM
Azadirachta indica	Yellow	Drupe	10.7	5.5	1	No	BM
Borassus flabellifer	Black	Drupe	-	-	-	Yes	M
Calophyllum inophyllum	Green	Drupe	31.3	29.5	1	Yes	M
Cassine glauca	Green	Drupe	10.2	5.7	1	No	M
Ficus amplissima	Green	Achene	13.6	-	multi	No	BM
Ficus benghalensis	Red	Achene	18.3	-	multi	No	BM
Ficus microcarpa	Yellow	Achene	7.3	-	multi	No	BM
Ficus racemosa	Red	Achene	27.8	-	multi	No	BM
Ficus religiosa	Red	Achene	7.7	-	multi	No	B
Lannea coromandelica	Red	Drupe	6.6	5.3	1	No	BM
Manilkara hexandra	Yellow	Berry	8.6	5.0	multi	No	BM
Mimusops elengi	Yellow	Berry	15.8	10.1	1	Yes	M
Phoenix sylvestris	Orange	Drupe	28.0	17.0	1	Yes	M
Strychnos nux-vomica	Orange	Berry	44.0	7.3	multi	Yes	M
Syzygium cumini	Black	Berry	14.7	7.3	1	No	BM
Tamarindus indicus	Brown	Pod	-	-	multi	Yes	M
Small Trees							
Atalantia monophylla	Green	Berry	22.3	3.8	multi	Yes	M
Canthium dicoccum	Black	Drupe	8.4	7.5	1	No	BM
Cordia dichotoma	Yellow	Drupe	8.9	4.8	1	No	BM
Diospyros ferrea	Red	Berry	11	8.2	multi	No	BM
Ehretia pubescens	Red	Drupe	4.6	2.6	multi	No	BM
Garcinia spicata	Yellow	Berry	30.0	11.3	multi	No	M
Lepisanthes tetraphylla	Yellow	Drupe	20.1	7.3	multi	No	BM
Ochna obtusata	Black	Drupe	8.3	5.5	1	No	B
Pamburus missionis	Yellow	Berry	21.8	10.7	multi	No	BM
Premna latifolia	Black	Drupe	5.9	2.3	1	No	B
Salvadora persica	Red	Drupe	8.0, 2.4	3.5	1	No	BM
Walsura trifolia	Brown	Berry	12.1	9.3	1	No	BM
Ziziphus mauritiana	Red	Drupe	20.2	9.5	1	No	M
Unidentified Species	White	-	4.6	-	1	No	B
Allophylus serratus	Red	Schizocarp	9.1	6.0	1	No	M
Breynia vitis-idaea	Red	Capsule	6.5	2.1	multi	No	B
Casaeria esculenta	Red	Aril	8.6	3.2	multi	Yes	B
Canthium parviflorum	Yellow	Drupe	11.8	10.9	1	No	B

Appendix 1: Fleshy-fruit species and fruit-traits in Sriharikota (*contd.*)

Species	Fruit Colour	Fruit type	Mean Fruit Size (mm)	Mean Seed Size (mm)	No. of seeds	Seed Protection	Consumer
Shrubs							
Capparis brevispina	Red	Berry	15.0	-	multi	No	B
Catunaregam malabarica	Black	Berry	8.2	1.4	multi	No	BM
Catunaregam spinosa	Green	Berry	20.0	-	multi	Yes	M
Eugenia bracteata	Red	Berry	10.0	7.6	1	No	B
Glycosmis pentaphylla	Red	Drupe	9.1	6.1	1	No	M
Grewia rhamnifolia	Brown	Drupe	11.4	4.7	multi	Yes	M
Memecylon umbellatum	Black	Berry	7.8	5.0	1	No	BM
Phoenix farinifera	Black	Drupe	7.4	6.8	1	No	BM
Securinega leucopyrus	White	Capsule	5.1	2	multi	No	BM
Climbers							
Calamus rotang	Yellow	Drupe	15.6	9.8	1	Yes	M
Cansjera rheedei	Red	Drupe	11.9	9.6	1	No	BM
Cissus vitiginea	Black	Berry	8	5.0	multi	No	M
Coccinea grandis	Red	Berry	21	2.7	multi	No	BM
Hugonia mystax	Red	Drupe	8.5	7.6	1	No	BM
Olax scandens	Yellow	Drupe	12.0	7.1	1	No	B
Opilia amentacea	Green	Drupe	14.4	11.4	1	No	M
Pachygone ovata	Red	Drupe	11.2	6.5	1	No	M
Salacia chinensis	Red	Berry	13.6	8.8	1 or 2	No	BM
Scutia myrtina	Violet	Drupe	10.0	6.6	multi	No	BM
Solanum trilobatum	Red	Berry	9.4	3.2	multi	No	BM
Ziziphus oenoplia	Black	Drupe	7.6	4.8	1	No	BM

Note: Fruits containing more than two seeds are categorised as 'multi-seeded'. For *Salvadora persica,* the 2nd value under mean fruit size is the diameter of seedless fruits. M: Mammals, B: Birds, BM: Birds and Mammals

Appendix 2: Frequency of occurrence of seeds in droppings of Golden Jackal, Small Indian Civet and Bonnet Macaque (June 2006-May 2008)

Species	Frequency of Occurrence (%)			Mean no. of seeds/scat and range		
	Jackal (n=473)	Civet (n=134)	Macaque (n=95)	Jackal	Civet	Macaque
Azadirachta indica	-	-	4	-	-	27 (14-44)
Allophylus serratus	-	-	1	-	-	-
Cordia dichotoma	15	10	15	91(12-214)	32 (6-86)	24 (2-34)
Catunaregam malabarica	1	-	-	-	-	-
Calamus rotang	3	1	4	28 (1-135)	-	39 (27-46)
Catunaregam spinosa	-	-	1			
Diospyros ferrea	5	4	4	82 (1-280)	20 (2-76)	18 (3-34)
Ficus spp.	0.2	-	14	-	-	-
Glycosmis pentaphylla	1	2	-	21 (1-93)	3 (1-6)	-
Grewia rhamnifolia	9	4	1	109 (1-372)	21(2-64)	-
Hugonia mystax	4	1	-	141 (1-316)	-	-
Lannea coromandelica	-	-	3	-	-	6 (5-8)
Lepisanthes tetraphylla	0.2	1	-	-	-	-
Mimusops elengi	0.4	-	-	20 (12-28)	-	-
Manilkara hexandra	3	3	-	30 (1-84)	13 (1-31)	-

Appendix 2: Frequency of occurrence of seeds in droppings of Golden Jackal, Small Indian Civet and Bonnet Macaque (June 2006-May 2008) (*contd.*)

Species	Frequency of Occurrence (%)			Mean no. of seeds/scat and range		
	Jackal (n=473)	Civet (n=134)	Macaque (n=95)	Jackal	Civet	Macaque
Memecylon umbellatum	14	19	4	87 (3-246)	61 (1-173)	52 (7-99)
Phoenix farinifera	18	18	1	105 (9-311)	47 (2-146)	-
Pamburus missionis	0.2	-	-	-	-	-
Pachygone ovata	-	-	3	-	-	2 (2-3)
Phoenix sylvestris	0.2	-	-	-	-	-
Scutia myrtina	0.4	1	-	2 (1-3)	119 (116-121)	-
Syzygium cumini	33	25	3	43 (1-89)	28 (1-121)	15 (2-40)
Securinega leucopyrus	1	7	-	-	-	-
Solanum trilobatum	0.2	-	-	-	-	-
Tamarindus indicus	1	1	3	9 (4-12)	-	7 (1-13)
Walsura trifolia	-	-	4	-	-	21 (17-25)
Ziziphus mauritiana	2	-	-	13 (1-37)	-	-
Ziziphus oenoplia	1	1	2	166 (64-354)	24 (19-30)	4 (1-8)

Note: *Lepisanthes tetraphylla*, *Mimusops elengi*, *Pamburus missionis* and *Ziziphus mauritiana* seeds were recorded in the scats of Bonnet Macaque prior to June 2006.

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WILD FOOD TRADITIONALLY USED BY THE INDIGENOUS PEOPLE OF PARAMBIKULAM WILDLIFE SANCTUARY, WESTERN GHATS, KERALA, INDIA

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This paper attempts an ethnobiological investigation, performed during 2003 to 2006, to collect, identify and document information on wild food traditionally used by the indigenous people of the Parambikulam Wildlife Sanctuary in Palakkad district of Kerala, India. During the investigation 83 species of plants were found to be used by the tribes as vegetables, wild fruits, beverages and in other preparations. Vegetables formed the largest group which included roots, tubers, young leaves and buds, inflorescence, ripe/unripe fruits and seeds.

Among fauna, 34 species of mammals, 65 of fishes, 3 of reptiles, 5 of frogs and toads, 10 of birds and 5 of insects were recorded to be used as food by tribals of the Sanctuary. Besides meat, other products like honey, larvae of honey bees, eggs of crocodile and birds are also consumed by the tribals. A paste of Red Ants *Oecophylla smaragdina* is eaten as a condiment with curry. The tongue of *Varanus* and meat of fruit bat is used to treat chronic asthma. Many food plants in the wild are also used for medicinal purposes such as *Amorphophallus paeoniifolius* (Dennst.) Nicol., *Boerhavia chinensis* (L.) Rottb. and *Ensete superbum*, which serve both as food and medicine. There is much scope for improving the quality of food resources in the wild by using modern agronomic research, experimental, cytogenetical and molecular studies.

Key words: traditionally eaten, indigenous people, Parambikulam Wildlife Sanctuary, medicinal, wild food

INTRODUCTION

Forests play an indispensable role in improving food security of indigenous people. Wild edible plants and animals are important in the livelihood strategies of forest dwellers/tribal populations. Leaves of wild species are among the most widely consumed. Besides leaves, they consume fruits, corms, shoots, seeds and young stem of plants.

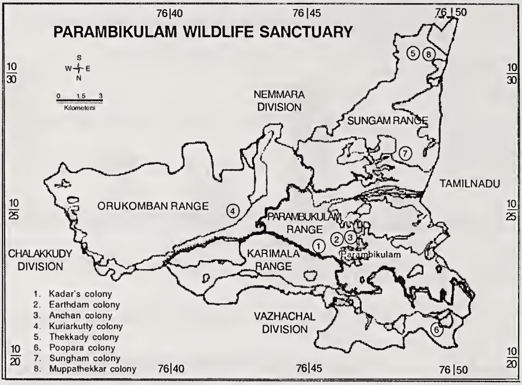
Tribal groups are selective in their animal food. They eat a variety of food items, including meat of several animals like tongue of *Varanus*, liver of peacock, eggs of crocodile. The even-toed ungulates are the chief source of meat. Rodents are also important meat animals in various parts of India (Mathur 1954). According to Bodenheimer (1951), insects are highly nutritious and provide plenty of proteins, fats, vitamins, salts and minerals. In the past, the meat of wild animals was the primary source of nutrition. They hunted the animals for bare necessity, and to provide essential nutrients to their diet. The larger society has very little knowledge of the nutritive value of edible products of forests. So, documentation of wild food resources is important for the food security of future generation. The surveys on wild edible plants and animals in India have been conducted by many researchers. This is the first attempt to document the wild food resources of Parambikulam Wildlife Sanctuary and its surrounding areas.

STUDY AREA

Parambikulam Wildlife Sanctuary is situated in Palghat district, Kerala state, India, with an extent of 274 sq. km between 10° 20'-10° 26' N and 76° 35'-76° 50' E. The Sanctuary is contiguous with the natural forests of Sholayar and Vazhachal in Thrissur district of the state. The boundary on the East is purely an administrative one with the forest clearance throughout the area bordered by Indira Gandhi Wildlife Sanctuary of Tamil Nadu. The Sanctuary is contiguous with forests of Anamalais, Nelliampathis, Sholayar high ranges and Palni hills. The major interception of the Western Ghats, namely the Palakkad gap, lies north of this area. The area in general has a slope towards west with the highest peak of Karimalagopuram (1,438 m) descending the banks of Chalakkudy river (439.5 m). The Sanctuary includes hilly terrains with undulated plateau. It spreads in the Sungam and Parambikulam valleys, which are well-known for teak plantation.

MATERIAL AND METHODS

The study was cnducted during 2003-2006. The aim of the study was to explore, collect, identify and preserve the wild and domesticated plants and animals used by the tribals


PARAMBIKULAM WILDLIFE SANCTUARY
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NEMMARA DIVISION
SUNGAM RANGE
TAMILNADU
ORUKOMBAN RANGE
PARAMBUKULAM RANGE
CHALAKKUDY DIVISION
KARIMALA RANGE
Parambikulam
VAZHACHAL DIVISION
1. Kadar's colony
2. Earthdam colony
3. Anchan colony
4. Kuriarkutty colony
5. Thekkady colony
6. Poopara colony
7. Sungham colony
8. Muppathekkar colony

Fig. 1: Study area of the Parambikulam Wildlife Sanctuary

as food, fodder, medicine, oil, tannin, gum, small timber, fuel, fibres, furniture, tools, musical instruments, game animals, socio-religious purposes, and domestic purpose. The data were collected from the tribals through a questionnaire survey. The paper reports a part of the study (Fig. 1), i.e., wild food resources used by the tribals of the Sanctuary. The elders, tribal medicine men (*Vaidyas*), and hunters were contacted to collect data on wild food resources. Local names, parts used, method of utilization were gathered from them with regard to each plant and animal species. The specimens collected were identified with the help of floras and taxonomic revisions, important books on animals, monographs and other field keys (Hooker 1872-92; Gamble 1915-35; Vajravelu 1990; Sasidharan 2002). Identification was later confirmed by matching the specimens with the authentic specimens available at Herbarium and Wildlife Museum of Kerala Forest Research Institute. All the specimens collected were incorporated in the herbarium of the Kerala Forest Research Institute at Peechi.

RESULTS AND DISCUSSION

During this study it was observed that the tribal communities of the Sanctuary fulfill deficiency in food needs by supplementing it with wild food plants and animals in their diet. The total agricultural produce of any tribal area is hardly enough for a few months to maintain their families. The tribals were well-acquainted with the food resources of surrounding forests, and knew what to eat and how to separate harmful substances from the edible items. For e.g. Corms and petioles of wild *Colocasia* or *Amorphophallus* when eaten raw cause a terrible itching sensation in the throat. To remove the irritable properties, they are peeled, boiled in tamarind water and smeared with turmeric paste. This is one of the methods devised in the kitchens of tribals to make wild plants palatable.

Of the 83 species of edible plants collected, 30 are used as leafy vegetables, 31 for fruits, 16 for seeds, 10 in the form of rhizomes/tubers/corms and 6 as stems/shoots. *Amaranthus spinosus*, *Centella asiatica*, *Euphorbia hirta*, *Oxalis corniculata*, *Mollugo pentaphylla* are used by tribals more extensively. Among wild fruits, consumption of Jackfruit *Artocarpus heterophyllus* and Mango *Mangifera indica* is common. *Vigna vexillata* and *Ensete superbum* are noted for suppressing hunger. In Table 1, plant parts such as seeds, fruits, rhizomes, leaves and stem used as food are listed alphabetically with their scientific names, local names and life form. Number of species of each category of food use and growth habit is given.

With regard to wild food items, forest fauna is in no way less important than forest flora. They not only add to the aesthetic value and grandeur of the forest, but also play an important role in maintaining ecological balance and act as food security for the rural people. Meat obtained from the fauna and the fish collected from the forest brooks, streams and ponds form a fair adjunct to the diet of the people. In this study, 65 species of fishes (Table 2), 34 of mammals, 10 of birds (Table 3), 3 of reptiles, 5 of frogs and toads (Table 4), and 5 of insects (Table 5) were recorded as food of Parambikulam Wildlife Sanctuary. Enumerated species and their products other than meat are also used as food (honey, larvae of honey bees, eggs of crocodile and birds). A paste made up of Red Ants (*Oecophylla smaragdina*) is eaten as a condiment with curry. Most of the observation claims that 'medicine is food and food is medicine'. The tongue of Varanus and meat of fruit bat is used to treat chronic asthma. Soup of Watercock *Gallicrex cinerea* and *Canis aureus* is a remedy for general weakness, which emphasizes that tribals take a balanced diet. Many food plants in the wild are also used for medicinal purposes, e.g., *Amorphophallus paeoniifolius* (Dennst.) Nicol., *Boerhavia chinensis* (L.) Rottb. and *Ensete superbum*. Every dish has medicinal properties. Considering the above factors the documentation of wild food resources is of utmost necessity.

Table 1: Wild edible plants utilized by tribals of Parambikulam Wildlife Sanctuary

Sl. No.	Scientific Name	Local Name	Habit
1.	*Acacia nilotica* Delile	Karivelom	Tree
2.	*Acacia sinuata* (Lour.) Merr.	Cheevakay	Climbing shrub
3.	*Acalypha fruticosa* Forssk.	Kuppameni	Undershrub
4.	*Adenanthera pavonina* L.	Manchadi	Tree
5.	*Aegle marmelos* (L.) Corr.	Koovalam	Tree
6.	*Alangium salvifolium* (L.f.) Wang.	Ankolam	Climbing shrub
7.	*Ailanthus triphysa* (Dennst.) Alston	Mattipal, Perumaram	Tree
8.	*Allmania nodiflora* Wt.	Ponnamkannicheera	Herb
9.	*Alternanthera sessilis* (L.) R. Br.	Kozhuppacheera	Prostrate herb
10.	*Amaranthus spinosus* L.	Mullancheera	Undershrub
11.	*Amaranthus viridis* L.	Pachacheera	Glabrous herb
12.	*Amorphophallus paeoniifolius* var. *campanulatus* Dene.	Kattuchena	Herb
13.	*Anacardium occidentale* L.	Kashumav	Tree
14.	*Antidesma montanum* Blume	Puliyilamaram	Tree
15.	*Artocarpus heterophyllus* Lamk.	Pilavu	Tree
16.	*Artocarpus hirsutus* Lamk.	Ayini	Tree
17.	*Asparagus racemosus* Willd.	Shatavari	Straggling shrub
18.	*Bambusa bambos* (L.) Voss	Illi	Armed bamboo
19.	*Boerhavia chinensis* (L.) Rottb.	Thazhuthama	Diffused herb
20.	*Calamus rotang* L.	Cheruchooral	Climbing cane
21.	*Canthium angustifolium* Roxb.	Malankara	Stout shrub
22.	*Cardiospermum halicacabum* L.	Pokanamthooki	Climber
23.	*Caryota urens* L.	Anappana	Palm
24.	*Cassia tora* L.	Thakara	Shrub
25.	*Celosia nodiflora* L.	Kozhivalan	Undershrub
26.	*Centella asiatica* (L.) Urban	Kodangal	Herb
27.	*Cissus quadrangularis* Wall	Changalamparanada	Climber
28.	*Cleome longata* L.	Kattukaduku	Herb
29.	*Cleome monophylla* L.	Kattukaduku	Undershrub
30.	*Cleome viscosa* L.	Kattukaduku	Herb
31.	*Coccinia grandis* W. &A.	Kattukoval	Climber
32.	*Cochlospermum religiosum* (L.) Alston	Appakaduka	Tree
33.	*Colocasia esculenta* (L.) Schott	Kattuchembu	Tuberous herb
34.	*Commelina bengalensis* L.	Thavalapottan	Herb
35.	*Costus speciosus* (Koenig) J. E. Smith.	Channakoova	Herb
36.	*Curculigo orchioides* Gaertn.	Nilapana	Herb
37.	*Curcuma neilgherrensis* Wight	Manjakoova	Herb
38.	*Cycas circinalis* L.	Enthal	Palm
39.	*Dendrocalamus strictus* Nees.	Kallan mula	Tufted bamboo
40.	*Dioscorea bulbifera* L.	Kattukachils	Tuberous herb
41.	*Dioscorea hispida* L.	Chava kizhangu	Tuberous herb
42.	*Dioscorea pentaphylla* L.	Nuaran kizhangu	Tuberous herb
43.	*Diospyros longata* Gurke	Panachi	Tree
44.	*Elaeocarpus serratus* L.	Kara	Tree

Table 1: Wild edible plants utilized by tribals of Parambikulam Wildlife Sanctuary (*contd.*)

Sl. No.	Scientific Name	Local Name	Habit
45.	*Ensete superbum* (Roxb.) Cheesm.	Kalluvazha	Tall herb
46.	*Entada rheedei* Spreng.	Kakkumkai	Shrub
47.	*Euphorbia hirta* L.	Nilapala	Herb
48.	*Garcinia gummi-gutta* (L.) Robs.	Karukampuli	Tree
49.	*Gmelina arborea* Roxb.	Kumbil, Kumil	Tree
50.	*Grewia tiliaefolia* Vahl	Chadachi	Tree
51.	*Hibiscus surattensis* L.	Chemeenpuli	Shrub
52.	*Ixora brachiata* DC.	Malathechi	Shrub
53.	*Lantana camara* L.	Koothadichipoov	Shrub
54.	*Mangifera indica* L.	Mavu	Tree
55.	*Mesua ferrea* L.	Nanku	Tree
56.	*Mimusops elengi* L.	Elengi	Tree
57.	*Mollugo pentaphylla* L.	Kozhuppacheera	Herb
58.	*Olea dioica* Roxb.	Edana	Shrub
59.	*Oxalis corniculata* L.	Pulyarila	Herb
60.	*Passiflora foetida* L.	Kurukkan pazham	Climber
61.	*Phyllanthus emblica* L.	Nelli	Tree
62.	*Piper longum* L.	Thippali	Scandent shrub
63.	*Piper nigrum* L.	Kattukurumulaku	Glabrous climber
64.	*Portulaca oleracea* L.	Kolambucheera	Herb
65.	*Pouzolzia zeylanica* (L.) Bennet	Kuppacheera	Procumbent herb
66.	*Sarcostigma kleinii* Wt. & Arn.	Odalvalli	Straggling shrub
67.	*Schleichera oleosa* (Lour.) Oken	Poovam	Tree
68.	*Semecarpus anacardium* L.f.	Vellacheru	Tree
69.	*Sida cordata (Burm. F.)* Bross.	Vallikurunthotty	Prostrate herb
70.	*Smilax zeylanica* L.	Kareenlanchi	Climbing shrub
71.	*Solanum nigrum* L.	Kattukathrica	Shrub
72.	*Solanum torvum* Sw.	Sukitti cheera	Shrub
73.	*Solanum violaceum* Ortega	Chunda	Shrub
74.	*Sterculia guttata* DC.	Pottakavalam	Tree
75.	*Sterculia urens* Roxb.	Thondi	Tree
76.	*Saccharum spontaneum* L.	Kattu karimbu	Grass
77.	*Syzygium cumini* (L.) Skeels	Kattunjaval	Tree
78.	*Tamarindus indica* L.	Puli	Tree
79.	*Terminalia bellirica* Roxb.	Thanni	Tree
80.	*Vigna radiata* (L.) Wilczek var. *radiata*	Kattupayar	Trailing herb
81.	*Vigna trilobata* (L.) Verdc.	Kattupayar	Trailing herb
82.	*Vigna vexillata* (L.) A.Rich.	Kattupayar	Trailing herb
83.	*Ziziphus rugosa* Lamk.	Vanthodali	Climbing shrub

Table 2: Fishes consumed by tribals of Parambikulam Wildlife Sanctuary

Sl.No.	Scientific name	Local name
1.	*Anguilla bengalensis* (Gray)	Mananjeen
2.	*Balitora brucei* Gray & Hard	Kalloty
3.	*Barilius bakeri* (Day)	Kulamchadi
4.	*Barilius barna* (Hamilton-Buchanan)	Kulamchadi
5.	*Barilius canarensis* (Jerdon)	Paral
6.	*Barilius gatensis* (Valenciennes)	Paral
7.	*Barilius kadamparaiensis*	Kulamchadi
8.	*Bhavania australis* (Jerdon)	Kalloty
9.	*Catla catla*	Catla
10.	*Chanda nama* (Hamilton, 1822)	Kannadi
11.	*Channa orientalis* (Bloch & Schneider)	Moyi/Varal/Thodan
12.	*Clarias dayi* Hora	Kadu
13.	*Clarias dussumieri* Valenciennes	Mushi
14.	*Cyprinus carpio communis* L.	Katla/Velimeen
15.	*Danio aequipinnatus* (McClelland)	Kannadi
16.	*Garra gotyla stenorhyncus* (Jerdon)	Kallemkeri
17.	*Garra hughi* (Hughi)	Kallemkeri
18.	*Garra itamalaiyarensis*	Kalloty
19.	*Garra mcclellandi* (Jerdon)	Kalloty
20.	*Garra mullya* (Sykes)	Kodali

Table 2: Fishes consumed by tribals of Parambikulam Wildlife Sanctuary (*contd.*)

Sl.No.	Scientific name	Local name
21.	*Glossogobius giuris (*Hamilton)	Kalloty
22.	*Glyptothorax housei* Herre	Kadu
23.	*Homaloptera montana* Herre	Kalloty
24.	*Hypselobarbus dubius* Day	Ponnukanda
25.	*Hypselobarbus kolus* Sykes	Eanthel/Kuzhikuthan
26.	*Labeo calbasu* (Hamilton- Buchanan)	Rohu
27.	*Labeo rohita* (Hamilton-Buchanan)	Chembolli
28.	*Mastacembelus armatus* (Lacepede)	Aral
29.	*Mystus armatus* (Day)	Puzhukoori
30.	*Mystus cavasius* (Hamilton-Buchanan)	Cheeku
31.	*Mystus montanus* (Jerdon)	Mullan
32.	*Nemacheilus denisoni denisoni* (Day)	Kalloty
33.	*Nemacheilus guentheri* (Day)	Kalloty
34.	*Nemacheilus moniiis* Hora	Kalloty
35.	*Nemacheilus moreh* (Sykes)	Koima
36.	*Nemacheilus ruppelli* (Sykes)	Koima
37.	*Neolissochilus anamalaiensis*	Pachilavetti karuppu
38.	*Neolissochilus wynaadensis* (Day.)	Pachilavetti vella
39.	*Ompok bimaculatus* Bloch	Kannadi
40.	*Ompok malabaricus* Valenciennes	Kari
41.	*Oreochromis mossambica* Peters	Thiloppia
42.	*Parluciosoma daniconius* (Hamilton-Buchanan)	Kanniyan
43.	*Peristolepis marginata*	Kallanthilopia
44.	*Pseudambassis ranga* (Hamilton-Buchanan)	Kannadi
45.	*Puntius amphibius* (Valencienes)	Modon
46.	*Puntius carnatius* (Jerdon)	Pachilavetti/Kadanna
47.	*Puntius chola* (Hamilton-Buchanan)	Poovaliparal/Kadukka
48.	*Puntius fasciatus* (Jerdon)	Puilamkotta chomappu
49.	*Puntius filamentosus* (Valenciennes)	Punnukothi/Poovaliparal
50.	*Puntius jerdoni* (Day)	Kooral
51.	*Puntius melanampyx* (Day)	Puilamkotta karup
52.	*Puntius poovarensis*	Kuvameen
53.	*Rasbora labiosa*	Kanniyan
54.	*Rasbora kannachiyarensis*	Kanniyanpennu
55.	*Salmo gairdeneriii* (Richardson)	Chalaparal
56.	*Salmo trutta fario* L.	Chalaparal
57.	*Salmostoma boopis* (Day)	Chalaparal
58.	*Tor anamalaiensis*	Pachilavetti
59.	*Tor khudree* (Sykes)	Kuyil/Kutti
60.	*Tor khudree malabaricus* Jerdon	Karimkuyil
61.	*Tor putitora* (Hamilton-Buchanan)	Chemkuyil
62.	*Tor tor* (Hamilton-Buchanan)	Karimkuyil
63.	*Travancoria elongata* (Pethiyagoda & Kottelat)	Kalloty
64.	*Travancoria jonesi* Hora	Kalloty
65.	*Xenentodon cancila* (Hamilton)	*Kolan*

Table 3: Birds and mammals consumed by tribals of Parambikulam Wildlife Sanctuary

Sl.No.	Scientific name	Local name
1.	*Anthracoceros coronatus* (Boddaert, 1783)	Malamuzhakki vezhambal
2.	*Athene brama* (Temminck, 1821)	Pullimoonga
3.	*Axis axis* (Erxleben, 1977)	Pulliman
4.	*Bandicota bengalensis* (Grey & Hardwicke, 1833)	Peruchazhi
5.	*Bos frontalis* (Lambert)	Kattupoth
6.	*Bubo nepalensis* (Hodgson, 1836)	Moonga
7.	*Bubulcus ibis* (Linnaeus,1758)	Vellakokku
8.	*Canis aureus* (Linnaeus, 1758)	Kurunari
9.	*Cervus unicolor* (Kerr, 1792)	Kalaman/Mlavu
10.	*Columba livia* (Gmelin, 1789)	Pravu
11.	*Corvus macrorhynchos* (Wagler, 1827)	Kattukakka
12.	*Corvus splendens* (Viellot, 1817)	Kakka
13.	*Cuon alpinus* (Pallas, 1811)	Kattupatti
14.	*Cynopterus brachyotis* (Muller, 1838)	Vawal
15.	*Cynopterus sphinx* (Vahl, 1797)	Kurumooken
16.	*Egretta garzetta* (Linnaeus, 1766)	Kokku
17.	*Funambulus layardi* (Blyth, 1849)	Varayannan
18.	*Funambulus tristriatus* (Waterhouse, 1837)	Kattuvarayannan
19.	*Gallicrex cinerea* (Gmelin, 1789)	Kulakozhi
20.	*Hystrix indica* (Kerr,1792)	Mullen panni
21.	*Lepus nigricollis* (F. Cuvier, 1823)	Muyal
22.	*Loris tardigradus* (Linnaeus,1758)	Kuttithevangu
23.	*Lutra lutra* (Linnaeus,1758)	Neernai
24.	*Macaca silenus* (Linnaeus,1758)	Simhavalan kurangu
25.	*Macaca radiata* (e.Geoffroy,1812)	Vella kurangu
26.	*Manis crassicaudata* (Gray, 1827)	Urumbutheeni
27.	*Megaderma lyra* (Geoffroy, 1810)	Kadavathil
28.	*Melursus ursinus* (Shaw, 1791)	Then karadi
29.	*Muntiacus muntjack* (Zimmerman,1780)	Kezhaman
30.	*Mus booduga* (Gray, 1837)	Kattuchundeli
31.	*Mus musculus* (Linnaeus,1758)	Chundeli
32.	*Pavo cristatus* (Linnaeus,1758)	Mayil
33.	*Petaurista petaurista* (Pallas, 1766)	Malambaran
34.	*Porphyrio porphyrio*	Neelakozhi
35.	*Trachypithecus johnii* (Fischer, 1829)	Karinkurangu
36.	*Pteropus giganteus* (Brunnich, 1782)	Parakkum kurukkan
37.	*Rattus bladfordi* (Thomas 1881)	Katteli

Table 3: Birds and mammals consumed by tribals of Parambikulam Wildlife Sanctuary

Sl.No.	Scientific name	Local name
38.	*Rattus rattus* (Linnaeus,1758)	Eli
39.	*Ratufa indica* (Schreber,1777)	Malayannan
40.	*Rousettus leschenaultii* (Desmarest, 1820)	Thavidan pazhavawal
41.	*Semnopithecus entellus* (Dufresne, 1797)	Hanuman kurangu
42.	*Sus scrofa* (Linnaeus,1758)	Kattupanni
43.	*Moschiola meminna* (Erxleben, 1777)	Kooranpanni
44.	*Vulpes bengalensis* (Shaw,1800)	Kurukkan

Table 4: Reptiles and amphibians consumed by tribals of Parambikulam Wildlife Sanctuary

Sl. No.	Scientific name	Local name
1.	*Varanus bengalensis* (Daudin, 1802)	Udombu
2.	*Euphlyctis hexadactyla* (Lesson, 1834)	Vazhathavala
3.	*Euphlyctis cyanophlyctis* (Schneider, 1799)	Thavala
4.	*Limnonectes limnocharis*	Pullithavala
5.	*Hoplobatrachus crassus* (Jerdon)	Thavala
6.	*Hoplobatrachus tigerinus*	Pockachithavala
7.	*Ptyas mucosus* (Linnaeus, 1758)	Cheera
8.	*Crocodylus palustris* (Lesson,1831)	Cheenkanni

Table 5: Insect food resources of Parambikulam Wildlife Sanctuary

Sl.No.	Scientific name	Local name
1.	*Apis cerana indica* (Fabricius, 1793)	Cheruthenicha
2.	*Apis dorsata* (Fabricius, 1793)	Kattuthenicha
3.	*Apis florae* (Fabricius, 1787)	Kolthenicha
4.	*Oecophylla smaragdina* (Fabricius, 1775)	Chonnurumbu
5.	*Patanga succinata* (Johansson, 1763)	Pulchadi

Thorough ethnobiological exploration of various tribal areas may reveal that many more plants and animals prove to be a cure for thirst or hunger depression problems in humans. There is much scope for improving the growth forms of wild food resources by using modern agronomic research, experimental cytogenetic studies. For all such endeavour, thorough field work in various tribal areas and critical ethnobiological observation on wild edible plants and animals are the basic requirements.

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NEW DESCRIPTION

A REVIEW OF THE WHITEFLY GENUS *DIALEUROLONGA* DOZIER (HEMIPTERA: ALEYRODIDAE) WITH DESCRIPTION OF A NEW SPECIES FROM INDIA

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The whitefly genus *Dialeurolonga* Dozier is represented in India by nine species. In this paper, *Dialeurolonga connari* sp. nov. infesting *Connarus sclerocarpus* from Kattapana (Kerala: India) is described and illustrated. Further, intra-specific variation observed in *D. malleshwaramensis* has been reported. A key to the Indian species of *Dialeurolonga* is given.

Keywords: Taxonomy, Aleyrodidae, *Dialeurolonga*, whitefly, new species, India

INTRODUCTION

Dialeurolonga Dozier is a whitefly genus with 53 hitherto described species (Martin and Mound 2007), majority of them known from Ethiopian and Malaysian regions; a few including the type species have been described from the Oriental region (Martin 1999). In India, *Dialeurolonga* is so far represented by nine species, namely *D. elongata* (Dozier), *D. lagerstroemiae* Jesudasan & David, *D. maculata* (Singh), *D. malleshwaramensis* Sundararaj, *D. davidi* Dubey & Sundararaj, *D. kumargiriensis* Dubey & Sundararaj, *D. multituberculata* Dubey & Sundararaj, *D. multipori* Dubey & Sundararaj, *D. pseudocephalidistincta* (Dubey and Sundararaj 2006). In this paper, a new species *D. connari* infesting *Connarus sclerocarpus* in southern India is described and illustrated raising the total number of Indian species of *Dialeurolonga* to ten. A key to the Indian species of the genus is given.

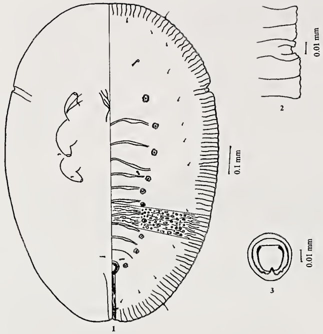
KEY TO THE INDIAN SPECIES OF *Dialeurolonga*

1. Submargin without a row of conical papillae; median pore cephalad of vasiform orifice absent 2
— Submargin with a row of conical papillae; cephalad of vasiform orifice a large median pore with a chitinised rim evident .... *elongata* (Dozier)
2. Laterad of vasiform orifice without enlarged kidney-shaped patches 3
— Laterad of vasiform orifice with enlarged kidney-shaped patches .... *davidi* Dubey & Sundararaj
3. Dorsum without tubercles or papillae 4
— Dorsum with tubercles or papillae 5
4. Subdorsum with a row of 8 pairs of curved minute setae; thoracic and caudal tracheal pores invaginated .... *kumargiriensis* Dubey & Sundararaj
— Subdorsum without a row of setae; thoracic and caudal tracheal pores indicated by six minute teeth .... *maculata* (Singh)
5. Subdorsal setae absent 6
— Subdorsal setae present 7
6. Thoracic and abdominal segments without submedian tubercles, but with spherical structure .... *lagerstroemiae* Jesudasan & David
— Dorsum completely tuberculate; submedian tubercles present, but without spherical structure .... *multituberculata* Dubey & Sundararaj
7. Puparium with enlarged submedian tubercles 8
— Puparium without enlarged submedian tubercles 9
8. Three to five pairs of enlarged submedian tubercles; subdorsum with 9-12 pairs of capitate setae .... *malleshwaramensis* Sundararaj
— A row of enlarged submedian tubercles extending from laterad of vasiform orifice to prothorax; subdorsum with 13 pairs of minute pointed setae .... *connari* sp. nov.
9. Margin smoothly crenulate; subdorsal setae capitate, less than 18 µm long; cephalothorax not separated by subdorsal furrow .... *multipori* Dubey & Sundararaj
— Margin irregularly crenulate; subdorsal setae with blunt end, 18-35.5 µm long; cephalothorax separated by a faint subdorsal furrow ....*pseudocephalidistincta* Dubey & Sundararaj

1. ***Dialeurolonga connari*** sp. nov.

(Figs 1-3)

Puparium: White, without secretion of wax; elliptical, broadest across prothoracic segment region, slightly indented at the thoracic tracheal pores; found in groups on the under surface of leaves; 1.18-1.24 mm long, 0.84-0.86 mm wide. Margin irregularly crenulate. Thoracic and caudal tracheal



Figs 1-3: *Dialeurolonga connari* sp. nov.
1. Puparium, 2. Margin at thoracic tracheal pore region, 3. Vasiform orifice

pores indicated. Anterior and posterior marginal setae, 8 µm and 10 µm long respectively.

Dorsum: Submargin with regularly arranged striations radiating from margin towards subdorsum; subdorsum with dense microtubercles; a submedian row of tubercles extending from laterad of vasiform orifice to prothorax; median area with transverse broken ridges, submedian pockets well-developed on all segment sutures. Longitudinal moulting suture reaching margin and transverse moulting suture reaching submedian area. Thoracic tracheal furrows indicated and caudal tracheal furrow sculptured, 164-172 µm long, 4-6 µm wide at its broadest end.

Chaetotaxy: Four pairs of capitate setae-cephalic setae 14 µm long, first abdominal setae 8 µm long, eighth abdominal setae cephalolaterad of vasiform orifice 6 µm long and caudal setae 8 µm long on caudal ridge. Subdorsum with 13 pairs of pointed setae 2.5 µm long.

Vasiform orifice: Subcircular, longer than wide (42.5-52.5 µm long, 43-45 µm wide), postero-lateral wall toothed with distinct tooth in the centre; operculum subcordate, 30-32.5 µm long, 27.5-30 µm wide. Lingula slightly exposed.

Venter: A pair of ventral abdominal setae 14 µm long, 44 µm apart. Antennae reaching base of prothoracic legs. Thoracic and caudal tracheal folds indicated without markings. A pair of setae at the base of meso- and metathoracic legs present.

Host: *Connarus sclerocarpus.*

Type Locality: Kattapana, Kerala, India.

Material examined: Holotype: One puparium, mounted on slide from *Connarus sclerocarpus.* Coll. R. Pushpa, 27.iii.2007, deposited in the collection of Forest Entomology Division, Forest Research Institute, Dehradun.

Paratypes: Nine mounted puparia, data same as holotype, deposited one each in the collections of Division of Entomology, Indian Agricultural Research Institute, New Delhi; Zoological Survey of India, Kolkata, and the remaining in the collection of Institute of Wood Science & Technology, Bengaluru.

Discussion: This species can be readily recognized from other known species of *Dialeurolonga* in shape: submargin with striations, subdorsum tuberculated, a row of 13 pairs of subdorsal setae and by the absence of stipples in thoracic and caudal tracheal folds.

Etymology: Named after the genus of its known host plant, *Connarus.*

2. ***Dialeurolonga davidi*** Dubey & Sundararaj

Dialeurolonga davidi Dubey & Sundararaj 2006. *Oriental Ins.* 40: 160.

Material examined: **Holotype**: puparium, INDIA: Karnataka: Kudremukh National Park, on unidentified plant, 10.viii.2001. Coll. A.K. Dubey.

Host: Unidentified plant (Dubey and Sundararaj 2006).

Distribution: INDIA: Karnataka (Dubey and Sundararaj 2006).

Discussion: This species is distinct from all known species of *Dialeurolonga* in having kidney-shaped patches laterad of vasiform orifice.

3. ***Dialeurolonga elongata*** Dozier

Dialeurodes (*Dialeurolonga*) *elongata* Dozier 1928. *J. Agric. Res.* 36: 1001-1005. *Dialeurodes elongata* Singh 1931. *Mem. Dep. Agric. India* 12 (1): 36.

Dialeurolonga elongata Takahashi 1951. *Mem. Inst. Sci. Madagascar* 6A: 345.

Jesudasan & David 1991. *Oriental Ins.* 25: 308-309.

Material examined: INDIA: Karnataka: Kudremukh National Park, 10 puparia, on *Tabernaemontana heyneana*, 8.viii.2001. Coll. A.K. Dubey.

Hosts: *Citrus* sp., *Ixora coccinea*, *I. pavetta*, *Litchi chinensis* (Singh, 1931); *Murraya exotica* (David & Subramaniam, 1976); *Tabernaemontana heyneana* (Dubey & Sundararaj, 2006).

Distribution: INDIA: Bihar: Pusa (Singh 1931); Tamil Nadu: Chennai (David and Subramaniam 1976); Karnataka: Kudremukh National Park (Dubey and Sundararaj 2006).

Discussion: This species is defined by its typical elongate shape, margin with wax tubes and dorsum uniformly pitted all over with a few papillae.

4. ***Dialeurolonga kumargiriensis*** Dubey & Sundararaj

Dialeurolonga kumargiriensis Dubey & Sundararaj, 2006. *Oriental Ins.* 40: 161.

Material examined: **Holotype**: puparium, INDIA: Karnataka: Kumargiri, on *Ficus nervosa*, 1.ix.2001. Coll. A.K. Dubey.

Host: *Ficus nervosa* (Dubey & Sundararaj, 2006).

Distribution: INDIA: Karnataka (Dubey and Sundararaj 2006).

Discussion: This species is rather distinct from the other known species of *Dialeurolonga* in the absence of subdorsal papillae or tubercles, presence of curved setae on subdorsum and invaginated thoracic and caudal tracheal pores.

5. ***Dialeurolonga lagerstroemiae*** Jesudasan & David

Dialeurolonga lagerstroemiae Jesudasan & David 1991. *Oriental Ins.* 26: 309-310.

Material examined: **Holotype**: puparium, INDIA: Uttar Pradesh (=Uttarakhand): Dehradun, on *Lagerstroemia speciosa*, 11.ii.1985. Coll. R.W.A. Jesudasan.

Host: *Lagerstroemia speciosa* (Jesudasan & David, 1991).

Distribution: INDIA: Uttar Pradesh (=Uttarakhand) (Jesudasan and David 1991).

Discussion: The puparium of this species can be recognized by its shorter seventh abdominal segment and presence of submedian granules on each of the abdominal segments.

6. ***Dialeurolonga maculata*** (Singh)

Aleurotulus maculata Singh 1931. *Mem. Dep. Agric. India* 12: 89.

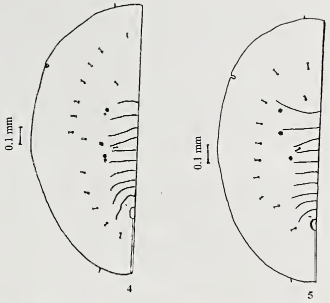
Dialeurolonga maculata David & Jesudasan 1989. *Entomon* 14: 371.

Material examined: INDIA: Tamil Nadu: Chennai, 1 puparium, on *Ficus religiosa*, 3.vii.1971. Coll. B.V. David.

Host: *Ficus religiosa* (Singh, 1931).

Distribution: INDIA: Bihar: Pusa (Singh 1931); Tamil Nadu: Chennai (Jesudasan and David 1991).

Discussion: This species is defined by its submargin with faint and irregular radial striations, vasiform orifice subcordate, operculum subrectangular with the corners rounded and caudal margin hairy, filling three-fourths of the orifice, lingula cylindrical with a swollen and setose tip projecting short distance beyond the caudal ridge and a narrow dotted groove runs from the end of the orifice to the caudal margin.



Figs 4-5: *Dialeurolonga malleshwaramensis* Sundararaj (Dorsal surface)
4. Puparium from upper surface, 5. Puparium from under surface

7. ***Dialeurolonga malleshwaramensis*** Sundararaj (Figs 4-5)

Dialeurolonga malleshwaramensis Sundararaj 2001. *Entomon* 26(2): 191-194.

Sundararaj (2001) described this species and Dubey & Ko (2006) redescribed it.

Material examined: INDIA: Karnataka: Bangalore, **Paratype**: puparium, on *Polyalthia longifolia*, 7.vii.1999. Coll. R. Sundararaj; Bengaluru, 14 puparia, on *Polyalthia longifolia*, 25.v.2007. Coll. R. Pushpa.

Host: *Polyalthia longifolia* (Sundararaj, 2001).

Distribution: INDIA: Karnataka (Sundararaj 2001).

Comments: Intraspecific variation has been observed in *D. malleshwaramensis* Sundararaj. The puparia, collected from upper surface of leaves, have more number of capitate setae and submedian tubercles (Fig. 4), while the puparia, on under surface of leaves have less number of capitate setae and submedian tubercles (Fig. 5).

Discussion: The puparium of this species is characterised by the presence of 4 pairs of blunt capitate setae, 3-5 pairs of enlarged submedian tubercles and subdorsum with 9-12 pairs of capitate setae.

8. ***Dialeurolonga multipori*** Dubey & Sundararaj

Dialeurolonga multipori Dubey & Sundararaj, 2006. *Oriental Ins.* 40: 162.

Material examined: **Holotype**: puparium, INDIA: Karnataka: Yellapur, on *Casearia esculenta*, 11.x.2001. Coll. A.K. Dubey.

Host: *Casearia esculenta* (Dubey & Sundararaj, 2006).

Distribution: INDIA: Karnataka (Dubey and Sundararaj 2006).

Discussion: This species can be easily separated from other known Indian species in having more number of subdorsal setae and their irregular arrangement and absence of tubercles on cephalothorax and abdomen, tassellation, vasiform orifice not notched at caudal end and excluded lingula.

9. *Dialeurolonga multituberculata* Dubey & Sundararaj

Dialeurolonga multituberculata Dubey & Sundararaj, 2006. *Oriental Ins.* 40: 163.

Material examined: **Holotype**: puparium, INDIA: Karnataka: Yellapur, on *Careya arborea*, 11.x.2001. Coll. A.K. Dubey.

Host: *Careya arborea* (Dubey & Sundararaj, 2006).

Distribution: INDIA: Karnataka (Dubey and Sundararaj 2006).

Discussion: The puparium of this species is readily recognizable by the presence of tubercles on whole of dorsum, notched vasiform orifice and distinct thoracic and caudal tracheal furrows.

10. *Dialeurolonga pseudocephalidistincta*
Dubey & Sundararaj

Dialeurolonga pseudocephalidistincta Dubey & Sundararaj, 2006. *Oriental Ins.* 40: 164.

Material examined: **Holotype**: puparium, INDIA: Karnataka: Kudremukh National Park, on unidentified plant, 10.viii.2001. Coll. A.K. Dubey.

Host: Unidentified plant (Dubey and Sundararaj 2006).

Distribution: INDIA: Karnataka (Dubey and Sundararaj 2006).

Discussion: This species is rather distinct from the other species of *Dialeurolonga* in having cephalothoracic fold on subdorsum and striations on lingula.

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REVIEWS

1. MANAGEMENT OF BIOLOGICAL DIVERSITY OF INDIAN FORESTS by S. Kondas. Published by Future Graphic, Chennai. Size: 14 cm x 23 cm, 500 pp., Paperback, Price: Rs. 390/-.

Here is a voluminous and scientific book largely free from the clutter of jargon and technical details. Written by a senior civil servant, who retired as PCCF of Tamil Nadu, it covers a wide array of information and details on biodiversity. In his foreword, noted agricultural scientist M.S. Swaminathan has said that biodiversity is the feedstock for plant, animal and fish breeding. He also highlights its importance for the future food, livelihood and health security.

The exhaustive range of biodiversity related topics covered in the book include physiographic divisions of forests of southern India, climate, morphology and floristics of forest vegetation, ecology and endemism, vegetation classification, forest tribes, anthropogenic pressures, sanctuaries and parks, biosphere reserves, climate change and global conventions, carbon credits and CDMs, bio-piracy and forest legislations, among others.

It also includes some interesting case studies on topics such as management of protected areas and some ecologically disastrous human interventions, e.g. shola forests in the Nilgiris and sugarcane cultivation in Kolhapur.

The book contains some good illustrations and photographs depicting the floral diversity, habitats and vegetation.

The book, which is reasonably priced, would be of interest to forest officials, researchers, policy makers, civil servants and students of forestry and agriculture, particularly those studying the forests of southern India.

However, it also has its share of drawbacks. There are several errors of commission and omission. In the list of highest peaks of Sahyadri in Maharashtra, the author has missed out Kalsubai, which is the highest. Description of the Konkan region is patchy and incomplete. For instance, while mentioning the rivers of Konkan, only a couple of rivers near Mumbai are mentioned, ignoring the dozens of other rivers in the region. In the islands section Andaman & Nicobar are mentioned, whereas Lakshadweep is missing. There are spelling mistakes in several chapters. The author switches from Indian to global issues at several places breaking the link of the reader.

Nevertheless, here we have a comprehensive book on biodiversity that touches the myriad topics therein, which will guide the reader about the basics. Thereafter, the reader can later refer to detailed books on each subject.

■ ATUL SATHE

2. BIRDS OF KERALA – STATUS AND DISTRIBUTION by C. Sashikumar, Praveen J., Muhamed Jafer Palot and P.O. Nameer. Published by DC Books, Kottayam, Kerala. Size: 14.5 x 22.5 cm, 835 pages, Hardbound, Price: not mentioned.

The BIRDS OF KERALA is a landmark publication on the avifauna of Kerala, and as the foreword by Dr. Asad R. Rahmani (Director, BNHS) says, is authored by "some of the most technically-sound ornithologists of India". Even from a quick perusal of the text of 835 pages and with 900 odd references, one gets a fair idea of the effort that went into the work and the authenticity of the information. As Dr. Rahmani says, the publication is a bench-mark standard for ornithologists of other states to emulate for publications on birds of their areas. Kerala was fortunate in having a dedicated native birder in K.K. Neelakantan, who inspired many of Kerala's birdwatchers, ornithologists and naturalists, and it is good to know that the tradition is continuing.

The publication is a document on the birds of Kerala, dealing primarily with their status and distribution. It describes 453 species of birds with mention of an additional 49 species that could occur in the state, which are grouped under *The Main List* and *The Secondary List*. There is a chapter on the history of ornithology of Kerala, which throws light on work and contributions of ornithologists from the days of the British Raj to Sálim Ali and K.K. Neelakantan. The landscape of Kerala, an overview of its bird communities, site descriptions and conservation issues are discussed in four introductory chapters. There is also a chapter on the nomenclature used, sequence of families, how the information and records were compiled, and the criteria used for inclusion of species into the state checklist. Overall, it is a work of erudition. Nevertheless, as with most publications, there is scope for improvement, mainly in the production aspects. In the next few paragraphs, I discuss these solely for consideration in the next revised edition.

Most of the species are illustrated by photographs, most are good or satisfactory. However, a few are of poor quality, which should have been avoided as it mars the publication somewhat. Attention should have been given to colour processing of the cover page – a blue cast is seen in the white areas of the birds' plumages. The maps on pages 88, 89 and 709 are rather gaudy and the font is also too bold. Lighter shades and a suitable font would have added to the aesthetics. It appears odd why the political map of Kerala, which should have figured along with the other maps in the introductory chapters, is placed towards the end of the book (page 709).

Coming to errors or inaccuracies, the title in pages 88 and 89 should read *Map* (and not Maps) *of northern Kerala* and *Map of southern Kerala*, as there is only one map for each page. The common (English) names follow Manakadan and Pittie (2001), but woodswallow is wrongly given as wood swallow (page 703). However, the authors got it right in the index (page 825)! Can't really blame them with all the confusion prevailing in the common names of Indian birds! Similarly, Wood-Owl is written as both Wood-Owl and Wood Owl (pages 415 and 416). The contents page cites *The Main List* in page 120, but this title does not figure in the page, unlike the case of *The Secondary List* on page 710. I suggest that "one single bird" and "a subadult bird was sighted" are replaced with "a single bird" (or better still "a bird") and "a subadult was sighted", as these sound better.

My main complaint with the publication is its unwarranted bulk. Size reduction could have been easily achieved by judicious page formatting (e.g., view the margins across pages 435 to 435) and by having small (*contra* half-page sized ones) photographs of birds next to the species accounts. One photo for each species would also do, unless the sexes are dimorphic, as this is not an identification guide. What was the justification for an illustration of a blurred image of a Jungle Crow with a deformed bill (page 708), when a good picture is already there on page 707? The use of bird illustrations in the chapter on the bird communities of the state is not really necessary. The indices could have had a three-column spread instead of two. The chapter on *Additional Information* (on species) could have been incorporated at the end of each species account to save space, besides having all the information on a species in one place. The appendix on pages 760-765 on locations of Sálim Ali's Travancore-Cochin Survey should have been given the bye. The chapters *The Changing Landscape of Kerala*, *Climate*, *Site Descriptions* and *Conservation* could have been merged and made crisper by deleting irrelevant information and neat editing. For example, pages 30 to 33 covering *The Changing Landscape of Kerala* are of too general nature and do not directly concern Kerala -- unlike the rest of the chapter. I suggest an integrated write-up of these four chapters covering the state's geography, drainages climate, forests, wetlands, land-use pattern and conservation issues. And, it is in this chapter, that extracts of locations and site descriptions of Sálim Ali's Travancore-Cochin Survey could be incorporated to show the changes taking place in the landscape over the years.

To end, I reiterate that the criticism and suggestions offered are solely for furthering the cause of good publications on Indian birds. Since book revision and publication have become much easier now with the advent of digital and printing technologies, I hope to see a much more compact edition in the near future, and after the authors judge this and other reviews.

■ RANJIT MANAKADAN

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MISCELLANEOUS NOTES

1. A NOTE ON WHISTLE ALARM CALLS OF THREE-STRIPED PALM SQUIRREL *FUNAMBULUS PALMARUM* LINNAEUS IN SITAMATA WILDLIFE SANCTUARY, RAJASTHAN, INDIA

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Alarm calls are vocalizations by an animal that can alert other animals of impending danger (Mateo and Holmes 1997). Among group-living animals, alarm calls would thus be expected to improve chances of evading an approaching predator (Schwagmeyer 1980). Sherman (1985), Lair (1990), Melchior (1971), Owings *et al.* (1986), Leger and Owings (1978), Smith (1978), and Zelley (1971) have studied many aspects of vocalization of ground and tree squirrels, but no work is available on vocalization of Indian species. Babu and Jayson (2009) have used call playback of conspecific owls in the forest of Tamil Nadu and Kerala to detect the presence of Indian Giant Flying Squirrel *Petaurista philippensis.* When owl calls were played back, the squirrel exposed itself by its characteristic calls. Rajamani (2001) studied some aspects of calls of the Small Travancore Flying Squirrel *Petinomys fuscocapillus* and Indian Giant Flying Squirrel *P. philippensis.* Though a few studies on flying squirrels are available, no work is available on vocalization in non-flying striped squirrels of India.

The Three-Striped Palm Squirrel *Funambulus palmarum* Linn. is found only in dense forests of southern Rajasthan. Its presence was recently reported by Sharma (2005, 2007) in the State. Not much work has been done on this species in Rajasthan. No information is available on vocalization of this squirrel. This is probably the first study on vocalization of *F. palmarum.*

On March 15, 2010, while wandering in Sitamata Wildlife Sanctuary, near Rana forest outpost, we noticed *F. palmarum* on a giant Mahua tree *Madhuca indica.* Since we had approached suddenly the squirrel started vocalizing alarm calls, probably out of fear. It was repeatedly calling while clinging to the upper surface of a horizontal bough. We captured its voice on a digital camera. The recorded sound was separated using Total Video Converter software into a

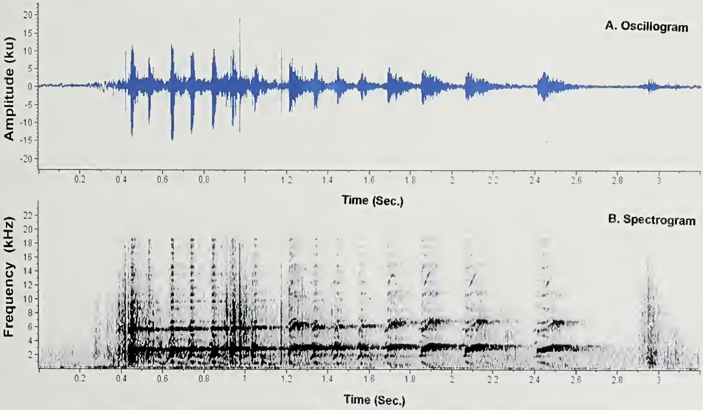

Fig. 1: Oscillogram (A) and Spectrogram (B) of one whistle alarm call bout of *Funambulus palmarum.* Each straight band represents a whistle alarm call

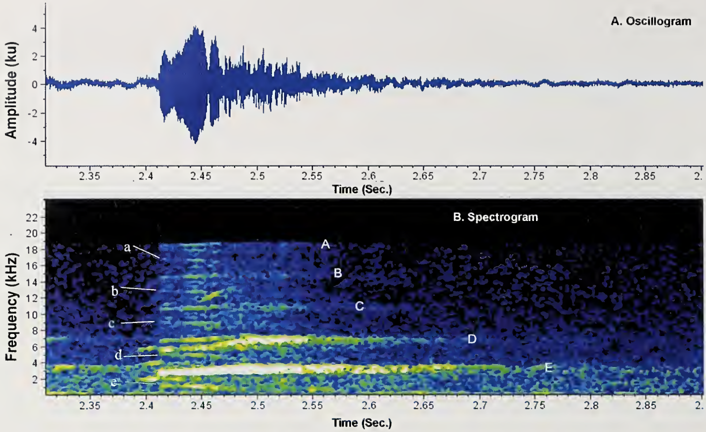

Fig. 2: Oscillogram (A) and Spectrogram (B) of one whistle alarm call of *Funambulus palmarum*. Spectrogram shows two type of bands; narrow bands (a, b, c, d and e) and broad bands (A, B,C, D and E)

wave audio file and analyzed with the help of the software Raven Pro 1.4.

On analysis, it was revealed that the whistle alarm call sounds consisted of a series of calls, which began and ended abruptly (Fig. 1). A total of 14 calling bouts were recorded; a few (n = 4) when *F. palmarum* ran along a tree bough. Mean call numbers of call bouts was 15 ±2.219 SD (max 20 and min 12). Mean duration of call bouts was 3.25 ±1.89 SD sec (min 1.60 sec and max 8.7 sec), and mean interval between calling bouts was 5.09 ±3.49 SD seconds (min 1.50 sec and max 12 sec). At the onset of a call bout, the first few calls were a high amplitude and towards the end, the amplitude of the calls became low (Fig. 1). Duration of calls was short initially and increased subsequently. Mean interval between two calls was 0.012 (±0.004 SD, n = 210) seconds and it increased in the last segment of the call bout. The last two calls contained the highest call duration (mean 0.35 ± 0.008 SD sec, n = 14).

The most pronounced characteristics of the calls are their harmonic nature. The call structure of *F. palmarum* contains variable flat bands in their spectrogram with variable duration (Fig. 2). A call spectrogram consists of a paired and periodic trajectory harmonics. Two type bands are present in the whistle alarm call spectrogram of *F. palmarum* – broad bands (A, B, C, D and E) and narrow bands (a, b, c, d and e). They are present in an alternative form. Duration of all narrow bands is 0.05 sec, but that of broad bands varies from 0.15-0.35 sec. The frequency range of one call is 1 to 18.5 Hz. Narrow bands are present on 1 (e), 5(d), 9(c), 13(b) and 17 kHz (a); broad bands are present on 18.5(A), 15(B), 11(C), 7(D) and 3(E) kHz in the spectrogram (Fig. 2).

The present study describes a type of alarm call of *F. palmarum*. Further studies are required on the vocalization and calls structure of this species, as it will help understand the communication pattern and social organization in tree dwelling squirrels.

We are grateful to the officials of the Sitamata Wildlife Sanctuary for providing facilities during study.

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2. ON A RECORD SPECIMEN OF GREY-HEADED GIANT FLYING SQUIRREL *PETAURISTA CANICEPS* GRAY, FROM ARUNACHAL, PRADESH WITH A NOTE ON ITS TAXONOMY

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The genus *Petaurista* is the most diverse among the flying squirrels. It has seven recognized species in India. These are the Red or Common Giant Flying Squirrel *Petaurista petaurista*, Indian Giant Flying Squirrel *P. philippensis*, Grey-headed Giant Flying Squirrel *P. caniceps*, Hodgson's Giant Flying Squirrel *P. magnificus*, Bhutan or Orange Giant Flying Squirrel *P. nobilis*, Mechuka Giant Flying Squirrel *P. mechukaensis* and Mishmi Hills Giant Flying Squirrel *P. mishmiensis*. However, a stable taxonomy for the giant flying squirrels of the genus *Petaurista* Link, 1795 remains elusive mainly owing to lack of sufficient specimens (as many of them live in remote mountains with difficult accessibility, hence, relatively fewer collection of several species). This is evident from the fact that two new species have been described recently from Arunachal Pradesh (Choudhury 2007, 2009a, b). I here report of a specimen of Grey-headed Giant Flying Squirrel *P. caniceps* Gray, from the same state, which appeared to be much larger than it is known.

P. caniceps was described from a specimen obtained in Nepal (Gray 1842). Ellerman and Morrison-Scott (1966) and Hoffmann *et al.* (1993) included it in *P. elegans*. It was reviewed by Corbet and Hill (1992) who upgraded it to a full species level. Ellerman (1961), while including it in *P. elegans*, had also considered the following forms as subspecies of *P. elegans* – *clarkei* and *gorkhali*, which are now synonyms of *caniceps*. The maximum total length recorded for *caniceps* was 77 cm with tail slightly longer than head-and-body (Corbet and Hill 1992).

In November 2002, I examined a skin of a male, which was killed about 2-3 months ago at Mechuka (28° 36' N; 94° 08' E) in West Siang district, Arunachal Pradesh. The elevation of Mechuka is 1,900 m above msl. The specimen measured 86 cm (total length, up to hair-tip at tail-end). Although it was in excellent condition, the head-and-body and tail lengths could not be measured separately with accuracy, as in flying squirrels the interfemoral membrane makes it difficult to determine the base of the tail unless the bone at the base remains intact (in this case the bone was absent).

It had a conspicuous grey head with a light rufous 'ring' around the eyes and a rich rufous patch around (posteriorly) the ears. Cheeks are also grey. There was a narrow black patch above the nose. Nostrils were light grey with a blackish median line. Dorsally it was almost uniform rufous brown. Black-tipped hairs could be seen anteriorly. Base of hair grey, which was prominent on the dorsum. Sides of parachute and upper portion of limbs were uniform rich rufous. Tail was similarly coloured as dorsum, but a black tip and an irregular line almost up to the base were noteworthy.

Ventrally, it was light rufous-buff with a slightly darker rufous median line from throat to lower abdomen. Parachute was rich rufous. Throat was conspicuous white while lower abdomen including genital region looked grey with buff. Tail was similarly coloured as dorsa, also with a black tip and an irregular line. On closer examination, some hairs in the anterior half of the tail had black at the centre with rufous tip, thus giving an overall rufous-brown effect. Feet were greyish-brown. This is the largest recorded specimen of *P. caniceps* so far.

The specimen is deposited at the national collections, Zoological Survey of India (Registration No. is ZSI 26087).

ACKNOWLEDGEMENTS

The visit to Mechuka was a part of the Important Bird Area programme coordinated by the Bombay Natural History Society and I thank them. I also thank Bikul Goswami (who was with me at Mechuka), Mamata Riba (Additional Deputy Commissioner, Mechuka), Ratul Talukdar and Hakim (both of the Rhino Foundation for Nature in NE India), and the anonymous owner (hunter) of the specimen belonging to the Tagin tribe for agreeing to send it to the Zoological Survey of India (ZSI). At the ZSI, I thank Dr. J.K. De, Scientist-'D' and Supriya Nandi.

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3. THE NORTHERNMOST RANGE OF GAUR *BOS GAURUS* H. SMITH AND WILD WATER BUFFALO *BUBALUS ARNEE* KERR

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The Gaur *Bos gaurus* H. Smith and Wild Water Buffalo *Bubalus arnee* (=*bubalis*) Kerr are large bovids; their current range is confined to mainland South and South-east Asia (Corbet and Hill 1992; Choudhury 2002, 2010). While the Gaur is more widespread and still has large populations in India, Bhutan, Myanmar, Thailand, Cambodia, Vietnam and Peninsular Malaysia (small populations in Nepal, China and Bangladesh), the Wild Water Buffalo is found in relatively small numbers, that too highly fragmented, in India, Nepal, Bhutan, Thailand and Cambodia (doubtfully in Myanmar) (Schaller 1967; Lekagul and McNeely 1977; Prater 1980; Corbet and Hill 1992; Choudhury 1994a,b, 2002, 2010; Groves 1996; IUCN 2009) (Fig. 1). In this short note, I discuss the northern limit of distribution of these bovids. Interestingly, the northernmost range limit of Gaur and Wild Water Buffalo is similar.

The Gaur ranges from the southernmost tip of India towards northern Western Ghats (well inside Maharashtra), to the plateau of Central India, Himalayan foothills from Nepal eastwards to Vietnam and up to Peninsular Malaysia (Dunbar Brander 1923; Hubback 1937; Gee 1952; Daniel and Grubh 1966; Choudhury 1994a, 2002; Duckworth *et al.* 1999). In South-east Asia, the northernmost populations are in southern China (Yunnan province) (*c.* 25° 00' N) (Smith and Xie 2008). Their range map indicates that their western limit was dry desert (during Indus Valley civilization it was apparently further west as Gaur appears in the seals of that period), to the south and east is the sea; while towards north are the high snow-capped mountains. The highest elevation where the Gaur has been recorded during this study was above 2,700 m in summer (near Chaku, Eagle Nest Wildlife Sanctuary), West Kameng district, Arunachal Pradesh. The Himalayas are above 5,000 m elevation and act as an impenetrable barrier. East of the Himalaya, are the Mishmi Hills, Gaoligong Shan, and other such high mountains, which have also prevented its northward spread. The northernmost area of its range lies in the Mishmi Hills, Lower Dibang Valley district, Arunachal Pradesh (Choudhury 1999); however, subsequent research in East and Upper Siang districts of Arunachal Pradesh revealed that it occurs farther north. The northernmost area of distribution of the Gaur is around Geku (*c.* 28° 30' N) in Upper Siang district. Historically, it perhaps

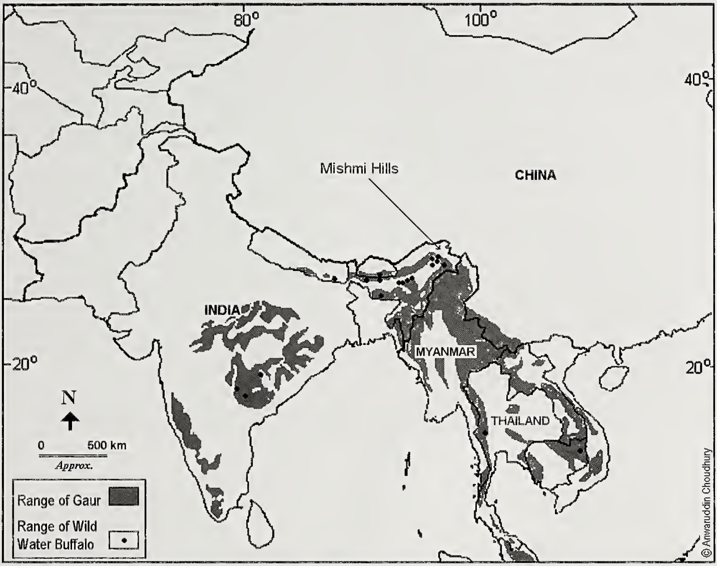

Fig. 1: Distribution of Gaur and Wild Water Buffalo showing their northernmost limit in Mishmi Hills, India (source of distribution are Choudhury [2002, 2010], Francis [2008] and Smith & Xie [2008])

occurred farther north of Yinkiyong (*c.* 28° 40' N) where human settlements and cultivations are present.

The Wild Water Buffalo is largely a dweller of flat plains or to some extent undulating country with smaller plains. The limiting factors or the zoogeographic barriers, however, seem almost similar to that of the Gaur. The Wild Water Buffalo might have extended farther west along the coastal plains (Choudhury 2010). The historic northerly animals were those occurring in the *terai* of northwestern Uttar Pradesh and western Nepal (Babur 1529; Fazl 1590). With the extinction of wild water buffaloes in those areas, the current northerly animals are those occurring in the plains just south of Mishmi Hills in the plains of the Dibang river (Choudhury 1998). The northernmost site where individuals were observed is Nizamghat (28° 18' N) where the Dibang river spreads out on the plains in Lower Dibang Valley district, Arunachal Pradesh. It is possible that a few buffaloes move farther north along the river or slopes for short distances.

It is an interesting coincidence that two of the largest bovids on earth have their northernmost range in the Mishmi Hills area of Arunachal Pradesh in north-east India.

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4. EASTERNMOST LIMIT OF THE RANGE OF BLACKBUCK *ANTILOPE CERVICAPRA* (L.) WITH HISTORIC RECORDS FROM ASSAM AND NORTH BENGAL, INDIA

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The Blackbuck *Antilope cervicapra* (L.) is an endemic antelope of the Indian subcontinent (Prater 1980; Menon 2003). It occurs in the grasslands and grass-scrub covered countryside amidst cultivations. Outside India, small numbers occur in Nepal and Pakistan (Roberts 1997). There is historic record from western Bangladesh (Asmat 2001). Being an animal of relatively drier opener plains, it apparently does not occur in high rainfall and densely forested areas of the Western Ghats, North-east India and the Himalayas.

Currently, the eastern range of the Blackbuck includes parts of Orissa and Jharkhand, may be lower parts of West Bengal too. Tikadar (1983) mentioned Chilka lake in Orissa as its eastern limit. Prater (1980) did not mention anything specific about its eastern range. Corbet and Hill (1992) mentioned West Bengal as the eastern range. Lydekker (1907) mentioned that Blackbuck extends to 'Lower Assam', but did not mention any specific locality. I here report the past occurrence of the Blackbuck, as far east as Assam, and also fix its easternmost limit of distribution.

The 'Raja' (landlord) of Gouripur, late Prabhat Chandra Barua in Assam's Dhubri district had shot a number of Blackbucks with his royal friends at different places, including Dholpur in present Rajasthan. He maintained his hunting records meticulously, most of which are still in good condition. In his records, there is a mention of shooting a Blackbuck from Jhalupara, near Sonahat (south-west of Golokganj near present India-Bangladesh border) in Assam's Dhubri district on January 13, 1915 (*c.* 26° 6' N; 89° 48' E). There were also past records from the banks of Manas river in western Assam by Pollock while a male obtained by F. Jenkins has been mentioned from 'Doon of Assam', which were mentioned by Sclater (1891). The 'Doon' of Assam is the *duar* region of undivided Goalpara district (now falling in Kokrajhar and Chirang districts). The banks of Manas (by Pollock in Sclater 1891) are likely to be somewhere in the Panbari range of Manas National Park or just south of it in present Chirang district.

In northern West Bengal, although Agrawal *et al.* (1992) did not mention any past occurrence, there are several records in the hunting accounts of 1908 of the Maharajah of Cooch Behar. This excellent hunting report not only provided important easterly records of Blackbuck, but also records of several other species. The Maharaja and his hunting parties, which also comprised of top British officials, had their

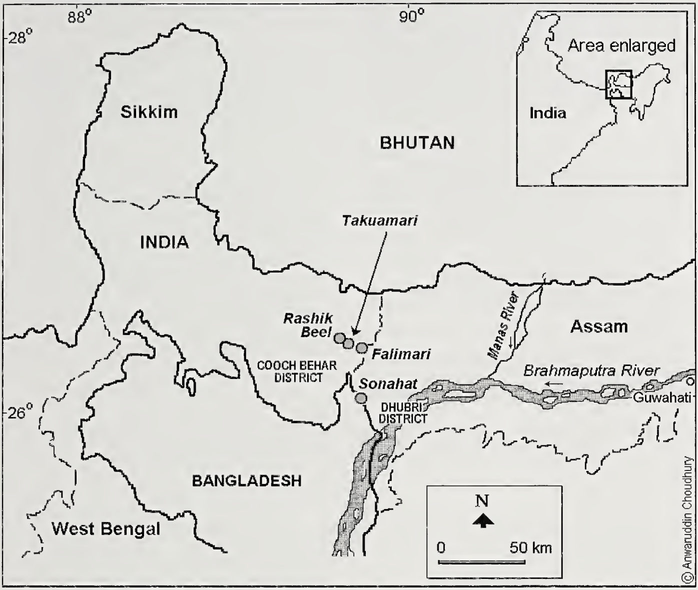

Fig. 1: Map showing the easternmost sites of confirmed shooting (●) of the Blackbuck in north Bengal and West Assam
The rivers Brahmaputra and Manas marked the eastern limit (latter being the easternmost)

shooting in present day Cooch Behar and Jalpaiguri districts of northern West Bengal and Kokrajhar, Chirang, Dhubri, Barpeta and Baksa districts of western Assam. The party had shot 7 Blackbucks in 1871, 2 in 1873, 1 each in 1877 and 1880, 3 in 1882, 2 each in 1883 and 1884 (2 shot near Rashik *beel*, Cooch Behar district on 31st March), 1 each in 1887 and 1888, 2 in 1889, 1 in 1890, 4 in 1891, 2 in February-March 1892, and 2 in 1896 (one on 27th March near Garad Haut, probably in Jalpaiguri district). Although many sites of shooting were not mentioned, two, i.e, Falimari (Phalimari) and Takuamari could be found in his account. Both these sites are located north of Boxirhat area in Tufanganj area near Assam-Bengal border (*c*. 26° 23' N; 89° 46' E; Rashik *beel*, Falimari and Takuamari are located around this coordinate). No Blackbucks were shot between 1897 and the end of his report in 1907, indicating its decline in the area. Its rarity in the area is also evident from the fact that only 31 Blackbucks were shot against 318 Swamp Deer or Barasingha *Cervus duvaucelii*, 296 Hog Deer *Axis porcinus* and 259 Sambar *Cervus unicolor* between 1871 and 1907.

In Bangladesh, Hunter (1876) had mentioned occurrence of 'Common' antilope in Rangpur. The site in Dhubri, Assam, i.e, Sonahat is near the border of undivided Rangpur district (now Kurigram district). On the Bangladesh side also, the area is known as Sonahat.

The above records show that the Blackbuck occurred up to lower Brahmaputra plains covering parts of western Assam till the turn of 19th century. Being its eastern extremity, it was very rare, especially in Assam. In case of north Bengal and northern Bangladesh (undivided Rangpur and Dinajpur districts), it was definitely present in small numbers till hunted out. Farther east, up to the Manas river, it was probably stray. The records by the Raja of Gouripur and the Maharaja of Cooch Behar also corroborate Pollock and F. Jenkins (in

Sclater 1891) and Lydekker (1907). Thus, it could be safely assumed that the Brahmaputra (precisely, its major distributary, the Jamuna in Bangladesh) and one of its major tributary, the Manas river marked the eastern limit of the distribution of the Blackbuck in the recent past, while the Manas river in Assam was the easternmost (*c*. 90° 54' E) (Fig.1).

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5. RANGE EXTENSION OF THE MOUNTAIN HAWK-EAGLE *NISAETUS* (=*SPIZAETUS*) *NIPALENSIS* TO UTTAR KANARA DISTRICT IN NORTHERN KARNATAKA, INDIA

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The Mountain Hawk-Eagle *Nisaetus* (=*Spizaetus*) *nipalensis* has two races in India, namely *nipalensis* Hodgson 1836, and *kelaarti* Legge 1878 (Ali and Ripley 1987; Naoroji 2006). *N.n. nipalensis* is recorded from northern India to north-eastern Hill states and eastern Himalayas. The other race, *kelaarti* has been observed in the Western Ghats from Kerala to central Karnataka (Grimmett *et al.*1999; Rasmussen and Anderton 2005; Naoroji 2006).

Narnali village (15° 19' N; 74° 78' E) in Haliyal taluka located in Uttar Kanara District, northern Karnataka, has a small percolation tank on the village boundary surrounded by degraded semi-evergreen forests. In January 2010, we spotted the Mountain Hawk-Eagle sitting on a *Terminalia tomentosa* tree at a height of 20 m. The bird was sitting there for 30 minutes unmindful of human activity around it. We saw the Eagle at the same location for two consecutive days.

Naoroji (2006) mentions his own observation of *N.n. kelaarti* near villages and disturbed forests in contrast with reports of this species requiring mature forests (Naoroji 2006).

The northernmost record of *N.n. kelaarti* is from BabaBudan hills in Chikmagalur district of Karnataka (Naoroji 2006). This sighting extends its range to Uttar Kanara district in northern Karnataka. Our observation also indicates that *N.n. kelaarti* can be seen near human habitations and degraded forests as mentioned by Naoroji (2006).

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6. SOME CHELONIAN RECORDS FROM MANIPUR AND NAGALAND IN NORTH-EAST INDIA

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Introduction

The states of Manipur (23° 49'-25° 42' N; 93° 00'-94° 45' E) and Nagaland (25° 10'-27° 01' N; 93° 17'-95° 15' E) are located in north-east India (Fig. 1). They fall in the Indo-Burma global biodiversity hotspot (Myers *et al.* 2000; Mittermeier *et al.* 2004) and the Eastern Himalaya Endemic Bird Area (Stattersfield *et al.* 1998). Manipur covers an area of 22,327 sq. km and is divided into nine districts (Bishnupur, Chandel, Churachandpur, Imphal East, Imphal West, Senapati, Tamenglong, Thoubal and Ukhrul). The state of Nagaland covers an area of 16,600 sq. km and is divided into 10 districts (Kiphire, Kohima, Longleng, Mokokchung, Mon, Peren, Phek, Tuensang, Wokha and Zunheboto).

Owing to its relative remoteness and also insurgency (still a major problem), fewer studies have been undertaken in Manipur and Nagaland in recent decades than in other neighbouring states, such as Assam and Arunachal Pradesh. The chelonian fauna are rather poorly known with only a few references to an odd specimen from the area (Anderson 1871; Smith 1931; Das 1985; Ahmed *et al.* 2008).

The present account describes the records of turtles and tortoises recorded during my surveys while making sporadic visits to Manipur during 1988-2001 and Nagaland during 1991-2004.

Study Area and Methods

Physiographically, almost all of Manipur is hilly and mountainous with a broad valley at the centre. Loktak, the largest freshwater lake (185 sq. km) in north-east India, lies to the south of the valley. The lowest elevation, (<50 m), is at the confluence of the Barak and Jiri rivers near the Assam border. Almost all of Nagaland is also hilly and mountainous. A high range exists along the border with Myanmar, and Mt. Saramati (3,842 m) is the highest point in the range and in Nagaland. The hills in the central areas are commonly referred to as the 'Naga Hills'. Small plains occur along the Dhansiri river, especially near Dimapur. The Barail range runs along the Manipur-Nagaland border. Patkai range is in north Nagaland. The highest peak of the Barail range is Mt. Japfu (Japvo) which stands at 3,043 m, which is in Nagaland. Mt Tenipu or Iso (2,995 m), also on the Barail range, is the highest peak in Manipur.

The climate of Manipur and Nagaland is tropical 'monsoon' type with a hot wet summer and a cool dry winter, although winter rains are not uncommon. The annual rainfall of these states varies from about 1,000 to more than 6,000 mm. The annual temperature generally ranges from less than 0° C in winter (minimum, especially on Mt. Saramati) to 35° C in summer.

Tropical wet evergreen, semi-evergreen and tropical moist deciduous forests occur in patches in the lower and middle elevations. In the higher hills, subtropical broadleaf (evergreen) forest occurs with small areas of conifers in the eastern areas. Higher up on Saramati, temperate broadleaf forest is found, while atop (Mt. Saramati) the vegetation type is subalpine. During winter, the peak remains under snow. In the abandoned *jhum* (slash-and-burn shifting cultivation of the hill tribes), various grasses occur till these are colonized by scrubs and then shrubs. It may be mentioned here that the *jhum* has greatly altered the original vegetation types all over

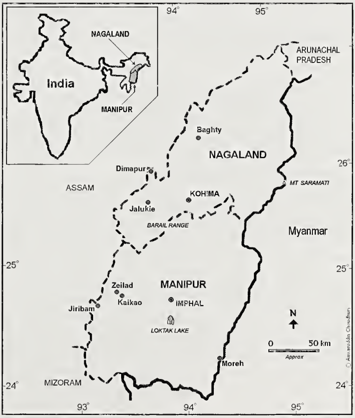

Fig. 1: Map of Manipur and Nagaland showing the areas surveyed

the hills of Manipur and Nagaland. In the Manipur valley, there is grassland in Keibul Lamjao National Park, which is on floating mats of vegetation, locally called as *phumdi*, composed of decaying vegetation.

Turtles and tortoises were searched for while conducting long-term work on the wildlife in general with focus on mammals and birds. Motor vehicles were used to reach the sites, especially tribal villages. Within the village, the movement was on foot. Specimens displayed outside tribal huts (usually all trophies are displayed outside) were examined and measured. Interviews were conducted to select houses that could have shells. In many villages, houses were randomly searched.

Elongated Tortoise *Indotestudo elongata* (Blyth 1853)

One shell (intact with carapace and plastron) and a broken carapace were examined and measured at Moreh (24° 14' N; 94° 18' E), Chandel district, Manipur in January 2001. Nuchal was prominent in the one having plastron (Table 1). The location is near the India-Myanmar border.

Das (1995) did not mention its occurrence in Nagaland. It has been recorded in Myanmar as well as Mizoram (Choudhury 2001). According to the collectors, these were captured from the forest of Yangoupokpi-Lokchao Wildlife Sanctuary (Manipur) or just outside it. The elevation of the capture sites ranged from 300 to 600 m above msl. They further reported that these are relatively easier to catch during burning for *jhum* when they take shelter in small unburnt patches.

Eastern Hill or Asian Brown Tortoise
Manouria emys (Schlegel and Müller 1840).

Three live tortoises were observed at Imphal zoo in January 2001, which were obtained from Jiribam subdivision, Imphal East district, Manipur, in 1996. A live turtle was seen at Kaikao village (24° 51' N; 93° 27' E; elevation: 1,000 m above msl), Tamenglong district, on January 22, 2001 (Table 1). It was caught by villagers from the bamboo area on hill slopes at 500 m above msl. One more was reportedly caught by the villagers. Normally the villagers wait for such prized catch in the dry season when they burn the hill side for *jhum*. While some are burnt to death, some take shelter in the unburnt patches or in streams (pers obs).

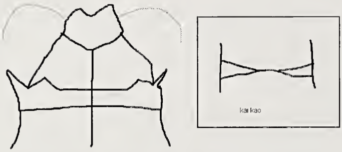

Fig. 2: Plastron patterns in *Manouria emys* (specimen from Nagaland at left and from Manipur at right)

A partly broken preserved shell was seen and examined at Jalukie, Peren district, Nagaland, on February 02, 2001 (Table 1). It was earlier reported from Nagaland by Anderson (1872). I had seen two specimens in late 1987 and 1989 at Sivasagar, Assam, which were brought by loggers from Nagaland (Mokokchung or Mon district).

Das (1995) did not mention its occurrence in Manipur. It has been recorded in Myanmar as well as Karbi Anglong district, Assam (Choudhury 1996a), North Cachar Hills (Dima Hasao) district, Assam (Anderson 1871, 1872) and Mizoram (Choudhury 2001).

Asian Leaf Turtle *Cyclemys gemeli* (Fritz, Guicking, Auer, Sommer, Wink & Hundsdörfer, 2008)

One preserved carapace was examined at Samjuram village, 3 km from Jalukie, Peren district, Nagaland, on February 02, 2001 (Table 1).

Das (1995) did not mention its occurrence in Manipur and Nagaland. It has been recorded in Myanmar as well as North Cachar Hills (Dima Hasao) district, Assam (Das 1995) and Mizoram (Choudhury 2001). The Indian population of *Cyclemys* is now considered as *Cyclemys gemeli* rather than *C. oldhami*. This species is among the common turtles found in North-east India, in the hill streams as well as on the forest floor.

Indian Black Turtle *Melanochelys trijuga*
(Schweigger 1812)

One preserved shell examined and measured at Moreh, Chandel district, Manipur, in January 2001. Its plastron was unmarked black (Table 1). According to the collectors, it was captured from near Lokchao river. The location is either in Yangoupokpi-Lokchao Wildlife Sanctuary (WLS) or just outside it. The elevation of the capture site was about 200 m above msl.

Das (1995) did not mention its occurrence in Manipur and Nagaland. It has been recorded in Assam (Ahmed *et al.* 2008), and Mizoram (Choudhury 2004).

Keeled Box Turtle *Cuora mouhotii* (Gray, 1862)

In Manipur, it was first recorded in Tamenglong district (Choudhury 1996b). A live turtle was seen at Kaikao village, Tamenglong district on January 22, 2001. It was caught by villagers from *jhum* fields. Its one eye was damaged due to *jhum* fire (Table 1). On January 24, 2001, a live turtle was

Table 1: Measurements of specimens mentioned in the text (in cm)

Specimen/Site	SCL	CCL	SCW	CCW	PL(gt)	PL (n-n)	PW	Remarks
Indotestudo elongata								
1. Moreh	20.9	24.9	14.7	23.0	-	15.3	11.4	Carapace height, *c.* 7.5
Manouria emys								
1. Jalukie	-	-	38.5	53.0	46.5	42.0	29.0	
2. Kaikao	38.0	-	-	-	44.0	40.0	-	
Cyclemys gemeli								
1. Samjuram	20.2	22.5	14.8	19.0	-	-	-	
Melanochelys trijuga								
1. Moreh	18.1	20.8	13.7	18.6	17.0	16.3	11.5	Carapace height, *c.* 6.5
Cuora mouhotii								
1. Kaikao	13.5	15.5	-	-	14.0	13.3	-	
2. Sempang	14.5	15.7	10.2	14.5	14.2	13.3	8.5	Shell height, *c.* 6.0; weight 425 gm

SCL=straight carapace length; CCL=curved carapace length; SCW=straight carapace width; CCW=curved carapace width; PL=plastron length; (gt)=greatest; (n-n)=notch to notch; PW=plastron width

caught by some villagers after burning of the hill slopes for *jhum* near Sempang village (24° 52' N; 93° 26' E; 750 m above msl), not far from Kaikao. Since it was kept for sale, I bought it for Rs. 30/- (Eastern Hill Tortoise was priced at Rs. 600) and released it after examination.

The interesting feature of this specimen was its carapace which was yellowish with dark (blackish or greenish-grey) blotches of irregular shape and often broken instead of brown without any blotches. The carapace was flat with three keels and prominently serrated marginals. The plastron was buffy and not yellowish-brown, as is usually found (Table 1). It was probably a female as was evident from the stripe on the sides of its face. It was deposited in Imphal zoo through a local NGO (Manipur Association for Science & Society).

Later, one more live animal was observed. The earlier record from Tamenglong (Choudhury 1996b) and the second live turtle recorded during the current study from almost the same area were of usual colouration. The habitat in the area was mostly degraded tropical wet evergreen rainforest with bamboo in old *jhums*, and current *jhum* clearings on hilly terrain in the basin of the Barak river.

In Nagaland, a carapace was examined at Baghty in Wokha district on February 19, 2004. No measurements were taken.

Das (1995) did not mention its occurrence in Manipur and Nagaland. It has been recorded in Myanmar, Karbi Anglong district, Assam (Choudhury 1993), North Cachar Hills (Dima Hasao) district, Assam (Das 1995), Assam-Mizoram border (Choudhury 1998) and Mizoram (Choudhury 2001).

Discussion

The chelonians of Manipur and Nagaland are relatively poorly known. This report provides some baseline data. It appears that except Eastern Hill Tortoise, there is no published record on the occurrence of other species observed during the study from these states (Das 1995). This is the first publication on chelonians of Nagaland. In case of Manipur, Linthoi and Sharma (2009) have published a brief report.

Several softshell species were reported from the Barak, Jiri and Makru rivers in Manipur and Dhansiri and Doyang rivers in Nagaland. Broken parts of shells of at least two species were seen, which could not be identified. One of the lakes in Zeilad Wildlife Sanctuary is known as Guiphuap lake (Guiphuap = turtle, in local Zeliangrong Naga dialect).

Although seven species (including two unidentified) have been recorded, occurrence of other species, such as *Pangshura* spp., is apparent owing to their records from adjacent areas. Linthoi and Sharma (2009) reported three additional species, namely *Amyda cartilaginea*, *Morenia petersi* and *Cuora amboinensis*.

The specimen of *Manouria emys* examined at Jalukie, Nagaland, resembled the subspecies *phayrei*. One of the Manipur specimens was intermediate between *emys* and the

Rangkhyang specimen of Das (1990) (Fig. 2). This indicates a complexity in the subspecific taxonomy of the species (Choudhury 1996c). According to villagers, *Manouria emys* and *Cuora mouhotii* are relatively common. But this may be owing to their easier capture during *jhum* burning.

Habitat destruction for *jhum* cultivation, logging, human settlements, poisoning and dynamiting of rivers for fish are reducing the favourable habitat for turtles and tortoises. Since all testudines are considered a delicacy in both Manipur and Nagaland (except the Manipuri Muslims), there is no scope of escape once they are spotted. During burning of hill forest for *jhum*, many species, especially *Indotestudo elongata*, *Manouria emys* and *Cuora mouhotii* are easy to catch. A new threat that could enhance poaching is demand for shells in Chinese medicine. Besides deer antler, tiger bone, and bear biles these too are smuggled. In addition to capture, during *jhum* burning, a number of turtles and tortoises are burnt to death or injured.

Conservation awareness is relatively poor in these states, although we had several meetings with locals. But unless local groups continue the effort, such sporadic awareness campaigns may not work.

The existing protected area network covers only 757.6 sq. km or *c*. 3.4% of Manipur. The protected areas are Keibul Lamjao National Park (40 sq. km), Shiroi National Park (100 sq. km), Bunning WLS (115.8 sq. km), Jiri-Makru WLS (198 sq. km), Kailam WLS (187.5 sq. km), Yangoupokpi-Lokchao WLS (184 sq. km) and Zeilad WLS (21 sq. km). Of these, disposal of claims and objections have not been completed except in Keibul Lamjao and Yangoupokpi-Lokchao. In Nagaland, it is only 1.33%. The protected areas are: Intanki National Park (202 sq. km), Pulie-Badge WLS (9.23 sq. km), Fakim WLS (6.42 sq. km), and Rangapahar WLS (4.70 sq. km). Except for Intanki, all are tiny and hardly cover a sizeable habitat. Moreover, the protection measures are very inadequate.

Formation of new protected areas such as Anko (400 sq. km), Dzuko (50 sq. km encompassing Dzuko-Tenipu), parts of Tolbung, Irangmukh and Vangai-Bongmukh Reserved Forests (500 sq. km) in Manipur; Saramati-Fakim (500 sq. km), Satoi (100 sq. km), Barails (200 sq. km; also encompassing within it Dzukou-Japfu areas), and Mt. Zephu (50 sq. km) in Nagaland, plus improved protection for existing sanctuaries, are recommended. Smaller community-run sanctuaries (up to 10 sq. km) should be established in the line of Khonoma Nature Conservation and Tragopan Sanctuary of Nagaland, which has been a success. The Forest Department should also start enforcing the Wildlife (Protection) Act, 1972, at least in the main markets of the hill districts. Within protected areas there needs to be better control of poaching, *jhum* cultivation and human-induced fires. Environmental awareness programmes are needed in villages surrounding protected areas.

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7. A REPORT ON THE PRESENCE OF THREE AVIAN LICE (INSECTA: PHTHIRAPTERA) IN DIFFERENT REGIONS OF NORTH-EAST INDIA

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Introduction

North-east India is one among the 12 mega biodiversity hotspots of the world. Of the 1,200+ known species of birds found in India about 60% have been reported from this region, most being passeriformes. These magnificent birds also act as host for many parasites consisting of a huge proportion of extant species (Price 1980). Among the ectoparasites, avian lice have a significant place and many birds in the wild are often infected by them (Keymer 1972). Parasitic lice (Phthiraptera) are the only major group of insects where all members are permanent parasites and spend their entire life on an animal host. Some show no habitat preference while most are host specific, feeding on only one or a few closely related species of animal hosts. They complete their entire life cycle from egg to adult on a single host species (Foster 1969) and survive only for a few days if separated from it. This association makes lice a suitable model system to study co-speciation between host and parasite (Johnson and Clayton 2003). Information on occurrence of avian lice and their host species in north-east India is scanty. Therefore, thorough and elaborate survey is required to report bird lice and their host species in the region. The present paper reports chewing lice parasitizing Tree Sparrow *Passer montanus* and Yellow-breasted Bunting *Emberiza aureola.*

Methodology

Tree Sparrows were captured using mist-net from different parts of Shillong, Meghalaya (25° 34' N; 91° 53' E) during different months in 2008-09. The Yellow-breasted Buntings are winter visitors to North-east India and were procured from Manipur (24° 35' N; 93° 59' E) during October-February 2008-09. Avian chewing lice were collected by visual examination of the areas around eyes, ears, head, back, legs, tail, body and wing feathers, particularly under surface of the remiges and wing coverts, systematically. Special attention was given to the ventral body feathers, skin and around the vent. The parasites were removed using a fine forcep, the tip dipped in alcohol, and preserved in 70% alcohol (Elizabeth 1951). They were then mounted on microscope slides for observation. Taxonomic identification of the lice was based on Ansari (1958), Hellenthal and Price (2003), Price *et al.* (2003). The taxonomy of birds follows Rasmussen and Anderton (2005).

We recorded three species of ectoparasitic chewing lice from two species of passerines, namely Tree Sparrow *Passer montanus* and Yellow-breasted Bunting *Emberiza aureola.* Two species of lice parasitized on sparrows and one species on buntings.

Chewing lice on Tree Sparrow *Passer montanus* Linn.

1. Family: Menoponidae
Genus: *Myrsidea* (Waterston)

Diagnostic characters: Head and thorax were broad and large in proportion to abdomen. Spines were absent on the ventral surface of the flatly rounded head. Head seta

23 absent. Temporal setae 26 and 27 not closely associated. No preocular slit or notch. Asters of spine-like setae present, sternites have 4 strong spines. Sclerite in the genital sec.

Myrsidea balati (Machácek)

The specimen was collected from a Tree Sparrow *Passer montanus* Linnaeus. Out of 60 birds examined, 25 were infected with 72 lice, which were collected for the study.

Place of collection: INDIA: Meghalaya: Different parts of Shillong, East Khasi Hill district.

Known host: *Passer montanus* L. (Passeriformes: Passeridae).

Remark: This is a host specific ectoparasite; it feeds on the feather and blood. This is the first report from Meghalaya, India.

2. Family: Philopteridae (Burmeister)

Genus: *Sturnidoecus* (Eichler)

Diagnostic characters: Broad temples, abdomen broadly oval, sub lateral row of normal setae clearly present in adult male and female, unclear ventrally, female subgenital plate have posteriorly pointed pigmented portion, distinctive male genitalia, a small additional plurite is present in segment V. The calyx is moderately developed.

Sturnidoecus ruficeps (Nitzsch in Giebel)

The specimen was collected from a Tree Sparrow *Passer montanus* Linnaeus. Out of the 60 birds examined, 20 were infected with 33 lice, which were collected for the study.

Place of collection: INDIA: Meghalaya: Different parts of Shillong, East Khasi Hill district.

Known host: *Passer montanus* L. (Order Passeriformes: Passeridae)

Remark: This is a host specific ectoparasite; it feeds on feathers. Reported for the first time from Meghalaya, India.

Chewing lice on Yellow-breasted Bunting *Emberiza aureola* Pallas

1. Family: Ricinidae (Neumann)

Genus: *Ricinus* (De Geer)

Diagnostic characters: Mouth inferior with two external lips and two hook-like mandibles. Tarsi distinct and articulated with two hooks. Head slightly elongated and articulated with prothorax by a rod-like structure. Two simple approximated eyes on each side of the head. Jaws with small palpus hidden by the lower lips.

Ricinus fringillae (De Geer)

The specimen was collected from a Yellow-breasted Bunting *Emberiza aureola*. Out of 48 birds examined, 16 infected with lice, which were collected for the study.

Place of collection: INDIA: Manipur, Tentha, Thoubal district.

Known host: No specific host. It has been reported on a number of bird species: *Bombycilla* (Bombycillidae); *Amphispiza, Emberiza, Junco, Melospiza, Passerella, Pipilo, Plectrophenax, Pooecetes, Spizella, Zonotrichia* (Emberizidae); *Acanthis, Carduelis, Carpodacus, Fringilla* (e.g., *F. coelebs*), *Pyrrhula* (Fringillidae); *Riparia* (Hirundinidae); *Anthus, Motacilla* (Motacillidae); *Parus* (Paridae); and *Passer* (Passeridae) among others.

Remarks: This species has no specific host and has been reported in representatives of several species of Passeriformes. This parasite has a rasping mouthpart and feeds entirely, if not exclusively, on the blood of its avian hosts. This has been reported for the first time in the present host from Manipur, India.

Discussion

Analysis of the present findings in light of available information on Indian chewing louse fauna reveals that this is the first report of three species of chewing lice on birds in the wild in North-east India. Members of genus *Myrsidea* and *Ricinus* (Foster 1969) are reported to be blood feeders, whereas those of genus *Sturnidoecus* are feather feeders. *Myrsidea balati* was reported for the first time by Machacek (1977) from its typical host *P. montanus*; it is a host specific ectoparasite. Other species of *Myrsidea* have been reported from different parts of India: *Myrsidea agarwali* on *Garrulax lineatus lineatus* (Khan *et al.* 2009); *M. sehri* on *G. l. lineatus* (Ansari 1951). *Sturnidoecus ruficeps* is a typical parasite of *Passer montanus*. It was earlier reported by Bechet (1961) as *Penenirmus ruficeps* along with its taxonomic history. Negru (1963) reported *S. ruficeps* from *Passer domesticus*. But, according to Price *et al.* (2003), *S. ruficeps* was found only on *Passer montanus*. The presence of chewing louse *Sturnidoecus* has also been reported in other birds, e.g., *Sturnidoecus sturnion* on *Sturnus vulgaris* L, *Sturnidoecus pastoris* on *Sturnus roseus* (Adam *et al.* 2009). The genus *Sturnidoecus* at present has 70 valid species identified so far that parasitize only the birds of Order Passeriformes. It is one amongst the most specious genera of Ischnocera. *Ricinus fringillae* has been hitherto reported from 47 species of avian hosts (Price *et al.* 2003; Adam *et al.* 2009). It was also reported from host *Emberiza citrinella* (Bechet 1956, 1962; Negru 1962). Many workers reported *Ricinus fringillae* under various synonyms along with the host, e.g., *Ricinus bombycillae* on *Bombycilla garrulus* (Bechet 1961, 1962; Negru 1962); *Ricinus irascens* on *Fringilla coelebs* (Bechet 1961, 1962); *Ricinus japonicus* on *Anthus spinoletta* (Negru 1959; Bechet 1961, 1962); *Ricinus subpallidus* on *Prunella collaris* (Negru 1963). Though *Myrsidea ananthakrishnani* (Rai 1978), *M. assamensis* and *M. manipurensis* (Tandan 1972) have been reported from North-east India, more research is required to document the avian louse in this region.

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8. REDISCOVERY OF *MURDANNIA STRIATIPETALA* (COMMELINACEAE) – A LITTLE KNOWN SPECIES FROM SOUTHERN INDIA WITH A NOTE ON ITS IDENTITY AND DISTRIBUTION

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Murdannia is a pantropical genus belonging to Family Commelinaceae with *c.* 50 species residing in warm temperate and a variety of open mesic or occasionally aquatic habitats, rarely in forests (Faden 1998, 2000). In India, the genus is represented by 24 species (modified after Karthikeyan *et al.* 1989) of which four species, one subspecies and one variety are endemic to Peninsular India and many of which are restricted to southern peninsular India (Ahmedulla and Nayar 1987).

While working on the revision of Indian Spiderworts, during exploration of localities, one of the authors came across a population of an interesting species of genus *Murdannia* at Thirumullaivoyal (04.ii.2010, 13° 12' 50" N; 80° 11' 49" E), on the banks of Red Hills lake, Chennai, Tamil Nadu (India) growing in a marshy area, 28 m above msl. After critical observation and referring available literature, the specimen was found to be *Murdannia striatipetala* Faden [MDN 204 (SUK)].

Murdannia striatipetala is a dazzling but little known species of southern India. It was described by Faden (2001) based on his earlier collection from Jaffna, Sri Lanka, in 1977. According to him, *M. striatipetala* is closely related to *M. spirata*, but characters such as definite base, narrow leaves, dark-veined petals, and short appressed hairs on the stamen and filaments had made it distinct. In addition, restricted habitat of *M. striatipetala* against widespread habitat of *M. spirata* was notable. Inflorescence of *M. dimorphoides* closely resembles *M. striatipetala.*

Contrasting dark-veined petals are also characteristic of *Murdannia spirata* (L.) Bruckner var. *parviflora* Faden (endemic to Sri Lanka, Faden 2001), but it differs from *M. striatipetala* by characters like indefinite base, flower *c.* 10-12 mm wide, stamen dimorphism, enantiostyly, lateral embryotega, etc. The distribution of this species was reported to be northern Sri Lanka and southern India, which Faden widened on the basis of earlier collections from India. He designated Indian collection as paratypes for *M. striatipetala* [Paratypes: INDIA: Districts unknown: Tambaram district, Chennai, Barnes 716 (K), 717 (K); Tada, Bourne 2784 (K); Nungambakam, 15.xi.1899, Bourne (from K. Rungachari) *s.n.* (K); Chinghput, Guindy, 1885, Lawson *s.n.* (K)] (Faden 2001). However, the deposition made earlier was not appropriately treated, while some were without names.

After detailed examination of specimen from mentioned locality and comparing the account by Faden, the authors observed that *Murdannia striatipetala* resembles *M. spirata* in vegetative forms except dark-veined petals. But short-lived flowers lasting for only few hours may be the reason for confusion of *M. striatipetala* with *M. spirata* resulting into negligence of species by post Bourne workers on Indian Commelinaceae.

All the paratypes were collected from Tamil Nadu state of India, namely Tambaram, (Kanchipuram district); Tada, (Nellore district); Nungambakkam and Guindy (Chennai district). Our present locality is at a distance of 25-60 km from all the above localities and elevation is not more than 28 m above msl. This additional data on its distribution confirms the noteworthy comments on the distribution of *Murdannia striatipetala* in southern India by Faden (2000).

Apart from the earlier collections by some workers, namely Barnes, Bourne, Rungachari and Lawson (1885-1899), the species is surprisingly neglected by descendents till date. *Murdannia striatipetala* is reported to be collected after a lapse of 111 years from southern India after Barnes and Bourne (1899). This species has not been included in any publication after Faden's identification. So the present work stands as the first proposal for the addition of *M. striatipetala* to Indian flora.

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9. *JUNCUS BUFONIUS* L. – AN ADDITION TO THE FLORA OF MAHARASHTRA, INDIA

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Introduction

The genus *Juncus* comprises of about 300 species (Mabberley 2002) varying from dwarf ephemeral annuals to large tufted or rhizomatous perennials. In India, the genus is represented by 44 species and 5 varieties (Karthikeyan *et al.* 1989). Two species of *Juncus* are so far reported for the state of Maharashtra, namely *Juncus maritimus* Lam. and *J. prismatocarpus* R.Br. (Shimpale 2008). The present paper reports *J. bufonius* L. from Tableland, Panchgani, in Satara district of Maharashtra. Description and nomenclature of the species along with a note are given for easy identification. The voucher specimens are deposited at the Herbarium of Botany Department, Shivaji University, Kolhapur (SUK).

Juncus bufonius L., Sp. Pl. 328. 1753; Hook. *f.*, Fl. Brit. India 6: 392. 1892; Fl. Upper Gangetic Plain 3: 282. 1920; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 3: 1553. 1928; Backer., Fl. Males. Ser 1. 4: 212, 1948; C.D.K. Cook, Aqua, & Wetl. Pl. India 223, f. 230, a & b. 1996; Tiagi & Aery. Fl. Rajasthan. 534-535. 2007.

Erect annual herb. Stems terete, up to 25 cm high, glabrous, striated, yellow-green. Leaves reduced to basal cataphylls, 5-12 cm long, 1-2 mm wide. Inflorescence a drepanium, 3-9 cm long; flowers small, 1-3 mm across, solitary, bracteate; bract 1, sheathing, open. Bracteoles 2. Tepals 6, free, lanceolate, straw-brown, keeled (outer tepals only) with a thickened midrib and scarious margin; outer tepals 4 mm long, exceeding inner tepals; inner tepals 3.5 mm long. Stamens 3, shorter than outer tepals; filament 0.9-1 mm long, hyaline; anthers 0.3-0.5 mm, hyaline. Ovary 1.8-2 mm long, ovoid, trigonous, hyaline; style trifid, 0.2-0.3 mm long, cylindric, brown. Capsule 3-locular, slightly shorter than tepals, ellipsoid, dark brown, shortly apiculate. Seeds 0.4-0.5 mm long, obovoid, yellowish-brown.

Flowering and Fruiting: September-March.

Distribution: INDIA: Himachal Pradesh, Delhi, Rajasthan, Sikkim, Maharashtra; temperate and warm regions of Eurasia and America; Sri Lanka; Bhutan; Nepal and Pakistan.

Specimens examined: INDIA, Maharashtra, Satara district, Panchgani, Tableland, 29.ix.2010, Lekhak-3896 (SUK).

Latitude and Longitude: 17° 55' N; 73° 48' E. Altitude: 1,413.96 m above msl.

Note: An erect herb that grows in seasonal ponds at Tableland in Panchgani. The typical associates were *Dopatrium junceum*, *Eriocaulon* spp., *Isachne* spp., *Oryza rufipogon*, *Rotala densiflora*, *Schoenoplectus* sp., and *Sopubia delphinifolia*.

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10. ADDITIONS TO THE FLORA OF SIMILIPAL BIOSPHERE RESERVE, ORISSA, INDIA

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Introduction

The concept of Biosphere Reserve was initiated by the UNESCO in 1970 as a global measure to promote *in situ* conservation of biological resources with the purpose of human welfare and sustainable development. Representative areas of natural and cultural landscapes, extending over terrestrial and coastal / marine ecosystems, with appropriate zoning pattern, resource base and management mechanisms have been designated as Biosphere Reserve. This approach is an effective mean of protecting the landscape along with its biodiversity. So far, 15 Biosphere Reserves have been established in India across different biogeographical regions. Similipal in Orissa was notified as the 8th Biosphere Reserve in June 1994, as the representative ecosystem under the Mahanadian biogeographic region in the eastern end of the Central plateau and Eastern Ghats of tropical eastern India. However, Similipal shares biotic features of all the four biotic provinces – Eastern plateau, Chhotanagpur, Lower Gangetic plain and East coast line – for which Orissa is the junction. Similipal Biosphere Reserve has a unique assemblage of a

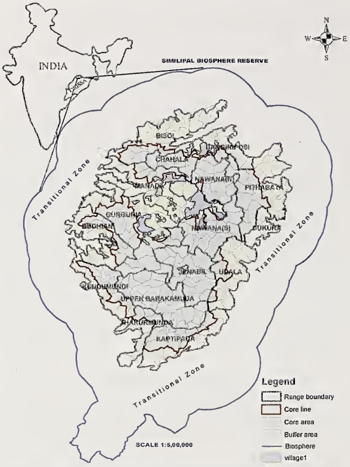

Fig. 1: Location of Similipal Biosphere Reserve, Orissa with 16 forest ranges

number of ecosystems, such as mountains, forests, grasslands and wetlands that congregate into a contiguous patch with a range of diverse vegetation types. Its rich floristic and faunal account of many indicator species makes the region a unique base for ecological studies. This biosphere reserve has varied topography, geologic formation, rich biological diversity and habitat of aboriginal / primitive tribes. It is called 'the Himalayas of Orissa' and controls the climatic regime of Orissa, part of Bihar, West Bengal, and other areas of eastern India influencing rainfall during monsoon season; it harbours the largest tropical peninsular sal zone forming a biological link between northern and southern India.

Location and spatial configuration

Similipal Biosphere Reserve is located in the central part of Mayurbhanj district of Orissa state, close to the interstate boundary with West Bengal in the north-east direction and Jharkhand in the north-west. It contains three protected habitats within its precincts, namely Similipal Tiger Reserve, Sanctuary and National Park. The Reserve is a compact mass of natural forests spread over an area of 5,569 sq. km lying between 21° 10' to 22° 12' N and 85° 58' to 86° 42' E, ranging between 300 m to 1,180 m above msl. The core area occupies 845 sq. km, which is intensively protected and absolutely undisturbed, secured legally and managed scientifically. The core zone includes Similipal Tiger Reserve and Similipal National Park. No biotic interference is permitted in the 2,129 sq. km buffer zone that surrounds the core zone. Limited activities of recreation, tourism, grazing and fishing, are permitted in the buffer zone with a view to reduce its effect on the core zone. The core and buffer zones of the Biosphere Reserve are under the administrative control of three forest divisions: Karanjia, Baripada and Rairangpur, which comprise of sixteen forest ranges, as traced in the map (Fig.1). The transitional zone extends over 2,595 sq. km, and is the outermost part of the Reserve encircling a belt of *c.* 10 km width around the buffer. This is a zone of collaboration where conservation knowledge and management skills are applied to foster alternative livelihood and reduce dependence on forest products. Most of the areas of this zone are under cultivation of field crops, such as paddy, mustard, til, and other vegetables practised by local people.

The flora of Similipal Biosphere Reserve exhibits a rich assemblage of species owing to its diversified hilly topography with lofty mountain crests and innumerable deep valleys, abundant springs, and specialized group of geological formation. The terrain and topography offer a congenial environment for the growth of plants including the rare / endangered ones restricted to this phyto-geographic region. The Reserve is located at the junction of four biotic provinces, and therefore shares multifarious floristic features of different geographic regions, such as Eastern Ghats, Deccan plateau, Lower Gangetic Plain and East Coastal zone. Thus, it has a unique biodiversity; it is of significance as it harbours a number of endemic, medicinal, economic and rare plants. The floral composition shows affinities towards northern and southern India, and Central table land due to a transitional bridge for migration of species from north to south or vice-versa. Diverse vegetation types prevailing in different landscapes and microclimates are found in Similipal, these include semi-evergreen forests along stream banks, damp valleys and deep gorges of high moisture content; moist and dry deciduous forests of high table lands along hill slopes and ridges; peninsular sal in ferruginous loams, loamy clays and red soils; and grasslands of exposed lofty plateau.

Past floristic work

The first attempt to identify the flora of Similipal hills is credited to Forester H.H. Haines (1921-25) who conducted an exploration trip to Similipal area of Mayurbhanj state, including Meghasini hills. On the contrary, none of the species mentioned by Mooney (1950) in his treatise is appended with Similipal hill ranges as locality of collection though he

Table1: Enumeration of additional taxa

Sl. No.	Family	Name of Species	Occurrence	Distribution	Fl. & Fr./ fertile period
1	Ophioglossaceae	*Ophioglossum reticulatum* L.	Munibasa, Rajapal, Saharpat	Common on forest floor during monsoon	Sep-Nov
2	Marsileaceae	*Marsilea quadrifolia* L.	Purunapani	Occasional in marshy places in forest edges	Nov-Feb
3	Thelypteridaceae	*Cyclosorus gongylodes* (Schkuhr) Link	Bakua nala	Occasional near water course	Nov-Dec
4	Aspidiaceae	*Tectaria cicutaria* (L.) Copel.	Solamundi	Occasional on foothills	Nov-Jan
5	Nephrolepidaceae	*Nephrolepis delicatula* (Decne) Pichi-Sermolli	Meghaseni	Occasional on foothills in shady places	Nov-Dec
6	Ranunculaceae	*Naravelia zeylanica* (L.) DC.	Sargil nala, Kasipani, Rajapala	Rare along streams in shady places	Oct-Apr
7	Annonaceae	*Alphonsea lutea* (Roxb.) Hook.f. & Thoms.	Ghatkumari, Misin nala	Occasional in dense moist habitat	Apr-May
8		*Polyalthia simiarum* Buch.-Ham. ex Hook.f. & Thoms.	Joronda	Rare near streams in damp valleys	Mar-Apr
9	Menispermaceae	*Tinospora cordifolia* (Willd.) Hook. f. & Thoms.	Barehipani	Occasional on foot hills	Feb-May
10	Malvaceae	*Abelmoschus crinitus* Wall.	Kolha, Nala near Ransa	Occasional on foothills near habitations	Sep-Oct
11		*Abelmoschus moschatus* Medic.	Kasipani, Kolha	Common on foothills near habitations	Aug-Oct
12		*Hibiscus platanifolius* (Willd.) Sweet	Kasipani, Munibasa	Occasional in dense and moist habitats	Feb- Apr
13	Sterculiaceae	*Guazuma ulmifolia* Lam.	Pithabata	Common on hill slopes in mixed forest	May- Feb
14		*Melochia corchorifolia* L.	Kukurbhuka	Common in forest edges during monsoon	Jul-Dec
15	Tiliaceae	*Triumfetta pentandra* A. Rich.	Kasipani	Common on foothills near habitations	Aug-Sep
16	Rutaceae	*Aegle marmelos* (L.) Corr.	Gurguria, Kasipani, Astakumar	Occasional in dry and moist deciduous forest	Mar-Apr
17		*Atalantia monophylla* (L.) Corr.	Ghatkumari, Kasipani	Occasional in forest periphery	Feb-Jun
18		*Chloroxylon swietenia* DC.	Ghatkumari, Kasipani, Bangiriposi	Occasional on hill slopes in dry forests	Mar-Jun
19		*Naringi crenulata* (Roxb.) Nicol.	Dantiakocha, Ghatkumari	Occasional on dry hill slopes	Apr-Nov
20	Opiliaceae	*Opilia amentacea* Roxb.	Barehipani,Chakundakocha, Misin nala	Occasional near stream course in dense forest	Apr-July
21	Celastraceae	*Cassine glauca* (Rotth.) Kuntze	Barehipani	Occasional in moist habitat	Sep-Dec
22	Rhamnaceae	*Ventilago maderaspatana* Gaertn.	Pithabata	Common on foothills in degraded habitat	Sep-Mar
23		*Ziziphus funiculosa* Buch.-Ham ex Lawson	Nigirdha, Kaduchapal	Common in moist habitats	Apr-Jun
24	Vitaceae	*Cayratia auriculata* (Wall.) Gamble	Kasipani, Ghatkumari	Common in shady and moist forest	July-Nov
25		*Cayratia pedata* (Lour.) Juss. ex Gagnep.	Kasipani, Kukurbhuka	Common in open scrublands	Aug-Dec
26		*Tetrastigma lanceolarium* (Roxb.) Planch.	Sargil nala	Occasional near streams under shade	Jan-Jul
27	Caesalpiniaceae	*Bauhinia acuminata* L.	Rajapal	Occasional in foothills of open forest	Jun-Aug
28	Mimosaceae	*Albizia odoratissima* (L.f.) Benth.	Pithabata	Common in moist valleys	Jun-Dec

Table1: Enumeration of additional taxa (*contd.*)

Sl. No.	Family	Name of Species	Occurrence	Distribution	Fl. & Fr./ fertile period
29	Fabaceae	*Crotalaria pallida* Ait.	Pithabata, Ghatkumari	Common in forest periphery near villages	Aug-Feb
30		*Crotalaria retusa* L.	Kasipani, Ghatkumari	Abundant along periphery near villages	Oct-Mar
31		*Desmodium pulchellum* (L.) Benth.	Sanuski, Chakundakocha	Frequent in moist forest	Oct-Feb
32		*Flemingia bracteata* (Roxb.) Wt.	Ghatkumari, Chakundakocha	Common on foothills and slopes	Nov-Feb
33		*Millettia racemosa* (Roxb.) Benth.	Munibasa, Bilapagha	Common on foothills and slopes	Feb-Jun
34		*Pseudarthria viscida* (L.) W. & A.	Ghatkumari, Kasipani	Occasional in shady areas	Nov-Feb
35	Myrtaceae	*Syzygium heyneanum* (Duthie) Wall. ex Gamble	Along Khairi river, Gudugudia	Common along river/nala	Apr-Jul
36	Lythraceae	*Ammannia multiflora* Roxb.	Phuljhari	Common in wet and muddy places	Oct-Feb
37	Passifloraceae	*Passiflora foetida* L.	Ghatkumari	Common in waste places	Nov-May
38	Cucurbitaceae	*Cucumis callosus* (Roettler) Cogn.	Bangriposi	Occasional in degraded forest near habitation	Oct-Mar
39	Molluginaceae	*Glinus oppositifolius* (L.) DC.	Pithabata	Common along river bank	Jan-Apr
40	Aizoaceae	*Trianthema portulacastrum* L.	Charabandh, Ghatkumari, Kasipani	Common on fallow fields near villages	Jun-Jul
41	Rubiaceae	*Benkara malabarica* (Lam.) Tirveng,	Bangiriposi, Kasipani	Common on foothills in open forest	Dec-May
42		*Canthium glabrum* Bl.	Sargil nala	Rare in moist valleys	Jul-Jan
43		*Canthium parviflorum* Lam.	Kasipani, way to Munibasa	Occasional along forest periphery	Apr-Dec
44		*Mitracarpus villosus* (Sw.) DC.	Kukurbhuka, Alapani	Common in moist places	Sep-Mar
45		*Spermacoce ramanii* Sivar. & Nayar	Gurguria, Kasipani	Common along forest edges	Sep-Jan
46		*Spermadictyon suaveolens* Roxb.	Astakumar	Common on moist hill slopes	Nov-Feb
47		*Tarenna asiatica* (L.) Kuntze & Schum.	Pithabata	Common on foothills in open forest	Dec-Apr
48	Asteraceae	*Chromolaena odorata* (L.) King & Robins.	Kasipani	Naturalized in open valleys	Nov-Mar
49		*Enydra fluctuans* Lour.	Pithabata, Sitakund	Occasional along river beds and on wet places	Dec-Mar
50		*Synedrella nodiflora* (L.) Gaertn.	Bangriposi, Kukurbhuka	Occasional in wet places	Sep-Feb
51	Ebenaceae	*Diospyros ferrea* (Willd.) Bakh.	Pithabata	Occasional in open valley	Mar-Jul
52	Apocynaceae	*Wrightia arborea* (Dennst.) Mabb.	Darbarmela pahad	Common in mixed deciduous forest	May-Dec
53		*Wrightia tinctoria* (Roxb.) R. Br.	Munibasa, Ghatkumari with scanty soil	Occasional in mixed deciduous forest	Apr-Dec
54	Asclepiadaceae	*Caralluma umbellata* Haw.	Darbarmela pahad	Occasional on fractured rocks	Jul-Dec
55		*Ceropegia hirsuta* Wt. & Arn.	Kaliani	Rare in moist forest	Jul-Dec
56		*Heterostemma tanjorense* Wt. & Arn.	Kasipani	Occasional in mixed deciduous forest	Nov-Feb
57		*Holostemma annulare* (Roxb.) Schum.	Ghatkumari	Occasional in moist valleys	Aug-Jan
58		*Wattakaka volubilis* (L. f.) Stapf.	Kairaburu, Dantiakocha	Common in open and mixed deciduous forest	May-Jan
59	Boraginaceae	*Coldenia procumbens* L.	Ghatkumari	Common in cultivated lands near villages	Nov-Feb
60		*Trichodesma zeylanicum* (Burm. f.) R. Br.	Kasipani	Occasional on foothills in degraded forest	Dec-May
61	Convolvulaceae	*Evolvulus alsinoides* (L.) L.	Char bandh	Common on degraded forest floor	Sep-Feb

Table1: Enumeration of additional taxa (*contd.*)

Sl. No.	Family	Name of Species	Occurrence	Distribution	Fl. & Fr./ fertile period
62		*Hewittia sublobata* (L.f.) Kuntze	Kasipani	Occasional in moist habitat in dense forest	Nov-Mar
63	Cuscutaceae	*Cuscuta reflexa* Roxb.	Kasipani	Occasional, climbing on shrubs in open areas	Nov-Feb
64	Solanaceae	*Physalis minima* L.	Kasipani	Common on foothills	Sep-Feb
65		*Solanum violaceum* Orteg.	Nigirdha	Common in open areas near habitation	Jan-May
66	Scrophulariaceae	*Bacopa monnieri* (L.) Pennell	Lulung	Occasional near water courses	May-Nov
67		*Lindernbergia muraria* (Roxb. ex D. Don) Bruhl.	Barehipani	Occasional on moist shady slopes	Oct-Feb
68		*Torenia cordifolia* Roxb.	Darbarmela pahad	Rare in damp shady places	Sep-Jan
69	Gesneriaceae	*Chirita hamosa* R. Br.	Kanthipani, Sleeping Kocha	Rare on moist moss-clad rock surface	Sep-Dec
70	Bignoniaceae	*Radermachera xylocarpa* (Roxb.) K. Schum.	Kairaburu, Ghatkumari	Rare in moist forest near stream	Mar-May
71	Martyniaceae	*Martynia annua* L.	Kasipani	Occasional in waste places near villages	Sep-Jan
72	Acanthaceae	*Blepharis maderaspatensis* B. Heyne ex Roth	Kasipani	Frequent on dry hill slopes in dry forests	Oct-Mar
73		*Eranthemum purpurascens* Nees in Wall.	Barehipani	Common in moist valleys	Sep-Jan
74		*Indoneesiella echioides* (L.) Sreemadh.	Kasipani	Common in open scrub forest	Sep-Jan
75	Verbenaceae	*Premna latifolia* Roxb.	Pithabata	Common in mixed deciduous forest	Apr-Jun
76		*Vitex negundo* L.	Nawana, Sanuski, Gurguria	Frequent on waste ground and pathways	Jul-Nov
77	Lamiaceae	*Leonotis nepetifolia* (L.) R. Br.	Pithabata	Common in forest periphery	Sep-Feb
78		*Leucas aspera* (Wild.)Link.	Kasipani	Frequent in open forest during monsoon	Jul-Jan
79		*Ocimum basilicum* L.	Sanakasira	Common in waste grounds near villages	Nov-Apr
80		*Orthosiphon pallidus* Benth.	Pithabata	Common on foothills in dry forests	Sep-Jan
81	Amaranthaceae	*Allmania nodiflora* (L.) R. Br. ex Wt.	Kasipani, Ghatkumari	Common near habitations in monsoon	Sep-Jan
82		*Amaranthus viridis* L.	Kukurbhuka, Basilakocha	Common in waste grounds and fallow lands	Aug-Dec
83		*Gomphrena celosioides* Mart.	Ghatkumari	Common in fallow lands	Oct-Jan
84		*Pupalia lappacea* (L.) Juss.	Kasipani, Barehipani	Frequent in open forests during monsoon	Sep-Dec
85	Lauraceae	*Cassytha filliformis* L.	Pithabata	Occasional in open scrub forests	Nov-Mar
86	Euphorbiaceae	*Acalypha indica* L.	Pithabata	Common in wastelands towards periphery	Sep-Jan
87		*Pachystylidium hirsutum* (Bl.) Pax & Hoffm.	Sargil nala, Nala near Ransa	Vulnerable in damp valleys along nala	Mar-May
88		*Phyllanthus amarus* Schum. & Thonn.	Kasipani	Common along forest edges	Aug-Dec
89		*Tragia involucrata* L.	Kasipani	Occasional in mixed dry deciduous forest	Dec-May
90	Moraceae	*Ficus heterophylla* L. f.	Kolha	Common along stream course in dense forest	Jan-May
91		*Ficus hispida* L. f.	Astakumar	Frequent in moist areas along forest periphery	Nov-Jun

Table1: Enumeration of additional taxa (*contd.*)

Sl. No.	Family	Name of Species	Occurrence	Distribution	Fl. & Fr./ fertile period
92		*Ficus lanceolata* (Miq.) Buch.-Ham.	Kadchapal	Occasional along streams in dense forest	Feb-Jun
93		*Ficus microcarpa* L. f.	Sarbil nala	Common in damp valleys	Nov-Apr
94		*Ficus nervosa* Heyne ex Roth.	Kadchapal	Occasional along streams in valleys	Feb-Jun
95	Urticaceae	*Elatostemma cuneatum* Wight	Nagpur pahad, Kasipani	Occasional on damp steep slopes and rocks	Nov-Dec
96		*Laportea interrrupta* (L.) Chew	San Uski	Occasional in moist shady places	Sep-Dec
97		*Pouzolzia auriculata* Wight	Kasipani, Barehipani	Occasional on moist fractured rocks/slopes	Aug-Nov
98	Zingiberaceae	*Amomum maximum* Roxb.	Dulmi pahad	Occasional near stream	Aug-Dec
99		*Curcuma zedoaria* (Christm.) Rosc.	Nigidha	Occasional on steep slopes in moist forest	Mar-Sep
100	Marantaceae	*Phrynium placentarium* (Lour.) Merr.	Sarbil nala	Occasional in damp valleys near streams	Dec-Apr
101		*Schumannianthus dichotomus* (Roxb.) Gognep.	Nala near Ransa	Occasional in marshy places along streams	Apr-Aug
102	Dioscoreaceae	*Dioscorea alata* L.	Gurguria	Occasional near settlements	Nov-Feb
103		*Dioscorea bulbifera* L.	Basilakocha, Kasipani, Nuniagada	Frequent in open moist forest	Aug-Jan
104		*Dioscorea belophylla* Voigt. ex Haines	Barehipani	Frequent in moist dense forest	Nov-Apr
105		*Dioscorea tomentosa* Koenig. ex Spreng.	Sanagandu	Occasional in moist slopes	Sep-Jan
106	Liliaceae	*Gloriosa superba* L.	Kasipani	Occasional in open scrub forest	Oct-Jan
107		*Drimia indica* (Roxb.) Jessop	Dulmi pahad, Kairaburu	Frequent on moist slopes	Mar-Jun
108	Commelinaceae	*Commelina benghalensis* L.	Kukurbhuka	Frequent in disturbed areas/ fallow lands	Oct-Dec
109		*Commelina diffusa* Burm. f.	Barehipani	Common in damp places	Sep-Dec
110		*Cyanotis fasciculata* (Roth.) Scult. & Scult.f.	Kasipani	Common on rock crevices with soil	Sep-Dec
111	Arecaceae	*Calamus viminalis* Willd. var *fasciculatus* Becc.	Chahala	Rare in damp places along stream course	Oct-Apr
112		*Caryota urens* L.	Sarbil nala	Rare in secluded damp valleys	Apr-Aug
113	Araceae	*Alocasia macrorrhizos* (L.) G. Don	Munibasa, Kanthipani	Common in damp wet places	Nov-Apr
114		*Amorphophalus paeoniifolius* var *campanulatus* (Dec.) Siv.	Kasipani	Common in forest periphery near villages	Mar-Nov
115		*Remusatia vivipara* (Roxb.)Schott	Nala near Ransa	Rare on rock crevices along dry stream	Apr
116		*Rhapidophora decursiva* (Roxb.) Schott	Misin nala near Chakundakocha	Rare, climbing on trees in damp valleys	Jun-Nov
117		*Theriophonum minutum* (Willd.) Baillon	Mayurpani, Ghatkumari	Rare in moist shady places near stream	May-Jun
118	Poaceae	*Saccharum narenga* (Nees ex Stud.) Hack.	Sargil nala	Occasional along moist valleys	Aug-Dec

recognized the region as one of the interesting spots rich in rare specimens, floristically. Panigrahi *et al.* (1964) undertook an exploration tour to Similipal during February 1958 and reported collection of 613 field numbers, belonging to 347 species. Misra (1989, 1997a, b) enumerated 94 species of orchids, of which 10 species were new record to the flora of Orissa, two were new additions for India and *Eria meghasaniensis* S. Mishra was new to science. Saxena and Brahmam (1989) made an exhaustive study on the flora of Similipal, which included findings of earlier workers and

Table 2: Comparative analysis of taxa of different plant groups

Plant groups	Earlier studies (Haines 1925; Panigrahi *et al.* 1964; Saxena and Brahmam 1989, 1994-96; Mishra 1997a,b)			Present study			Additional taxa incorporated		
	Family	Genera	Species	Family	Genera	Species	Family	Genera	Species
Pteridophytes	28	42	60	31	46	65	3	4	5
Gymnosperms	3	4	4	3	4	4	-	-	-
Dicotyledons	114	446	747	119	496	839	5	50	92
Monocotyledons	24	159	325	25	169	346	1	10	21
Total	169	651	1,136	178	715	1,254	9	64	118

observation of their field survey and recorded 1,012 species of vascular plants besides 64 species of cultivated taxa. Bal (1942) and Yoganarsimhan and Dutta (1972) have published an account of the useful plants and medicinal plants of Mayurbhanj district and Similipal forest, respectively. Later, Misra (1997a) provided an account of 52 species of rare and endangered plants of Similipal Biosphere Reserve based on field observation and reference of literature. Very little has been added thereafter regarding ethnobotany, flora of lower plants and other floristic aspects of the region.

Two decades have elapsed since Saxena and Brahmam (1989) published the floristic account of Similipal. This treatise, however, did not cover many plant species found in the core and buffer zones. Several floristically rich and economically potential localities were partly explored and a number of unreported plant species are expected to occur in such a diversified floristic region. Besides, there has been a considerable change in vegetation pattern during the last two decades, which is more likely due to biotic interferences and habitat loss/conversion of forest to agricultural lands and introduction of exotic species / aliens into the nearby valleys, which necessitated a further exploration.

Methodology

The present work is based on the results of intensive floristic survey done during 2007-2009 in different seasons, for which eight field trips were undertaken to explore the area and to observe the changes in the floristic biodiversity. The core and buffer areas have been surveyed on foot across various eco-zones and vegetation types on a tentatively trimonthly basis with increasing frequencies of visit during the monsoon to record the ground flora. Effort was made to record the species not documented earlier. Plant specimens were collected in flowering or / and fruiting stages. The specimens were brought to the centre for morphological observations and identified with the help of Saxena and Brahmam (1994-96) and other relevant literature. During the field studies, detailed notes on habit, habitat, botanical description, colour of the flower and other prominent features were recorded. The specimens were processed and a herbarium of voucher specimens prepared, checked with authenticated herbarium sheets, and deposited in the herbarium of Regional Plant Resource Centre, Bhubaneswar. In addition, photographs of many plants were taken in the field for record and thorough observation.

Results and Discussion

The aim of the present study was to record occurrence of species to supplement the flora of Similipal Biosphere Reserve and undertake a comparative analysis of existing plant species in Similipal with taxa documented earlier (Haines 1921-25; Mooney 1950; Panigrahi *et al.* 1964; Saxena and Brahmam 1989, 1994-96; Misra 1997a, b). All such additional plant species are enumerated in Table 1.

The revised assessment led to new records of 118 species from the Similipal Biosphere Reserve. These constitute 92 species of dicotyledons and 21 species of monocotyledons. Besides, new records of 5 species, 4 genera and 3 families of pteridophytes were made. The genus and species within the family follow in alphabetical sequence. A brief citation on the occurrence of species, their general distribution within the Biosphere Reserve, and flowering and fruiting time has also been provided. All the species recorded in this present enumeration are wild or naturalized. Some of the species excluded from the earlier account were collected and recorded in the present study.

A total of 9 families were added to the recorded taxa, namely Ophioglossaceae, Aspidiaceae and Nephrolepidaceae to pteridophytes; and Opiliaceae, Passifloraceae, Aizoaceae, Cuscutaceae, Martyniaceae and Marantaceae to dicotyledons and monocotyledons.

A comparative analysis of taxa of different plant groups

Table 3: Comparative list of ten dominant angiosperm families in Similipal Biosphere Reserve, Flora of Orissa, Bihar-Orissa and British-India

Order of dominance	Similipal Biosphere Reserve (Present study)	Flora of Orissa, Saxena & Brahmam, 1994-96	Bihar & Orissa Haines, 1921-25 & Mooney, 1950	British India J.D. Hooker, 1872-97
1.	Poaceae	Poaceae	Leguminosae	Orchidaceae
2.	Orchidaceae	Fabaceae	Graminae	Leguminosae
3.	Fabaceae	Cyperaceae	Cyperaceae	Graminae
4.	Asteraceae	Orchidaceae	Asteraceae	Rubiaceae
5.	Rubiaceae	Asteraceae	Euphorbiaceae	Euphorbiaceae
6.	Euphorbiaceae	Euphorbiaceae	Acanthaceae	Acanthaceae
7.	Cyperaceae	Rubiaceae	Rubiaceae	Compositae
8.	Acanthaceae	Acanthaceae	Orchidaceae	Cyperaceae
9.	Lamiaceae	Scrophulariaceae	Labiatae	Labiatae
10.	Scrophulariaceae	Lamiaceae	Scrophulariaceae	Urticaceae

recorded from earlier studies and found in the present study is given in Table 2. The present estimate reveals that there is an increase in composition of taxa of each plant group increasing the number of species from 1,136 to 1,254, genus from 651 to 715 and family from 169 to 178. There is an overall increase of 10.4% species, 9.83% genera, and 5.32% families.

A comparative account of ten dominant angiosperm families with respect to number of species in the flora of Similipal Biosphere Reserve (present study), Orissa, Bihar and Orissa and British India is presented in Table 3. In terms of species content, Poaceae, Orchidaceae and Fabaceae occupy the first, second, and third position respectively consisting of 108, 94 and 82 species followed by Asteraceae (58 species), Rubiaceae (52), Euphorbiaceae (47), Cyperaceae (43), Acanthaceae (40), Lamiaceae (28) and Scrophulariaceae (23). The present analysis records the ratio of monocots to dicots as 1:4.76 for families, 1:2.93 for genera and 1:2.42 for species against previously recorded 1:4.75 for families, 1:2.80 for genera and 1:2.29 for species, respectively. The present ratio of family to genera to species is 1:4.02:7.04 against 1:3.85:6.72 in the previous assessment. Thus, the total species assessed in the present floristic estimate for Similipal is 1,254, which represent 46% of the flora of Orissa against previously recorded 39.45% (Saxena and Brahmam 1989).

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Cover Photograph: Bar-headed Goose *Anser indicus* by Nayan Khanolkar

Editorial

Mudflats: The Cradle of Life

The purported aim of the National Biodiversity Action Plan of the Government of India is to protect all species and all types of habitats. However, in the priority list of the Ministry of Environment & Forests and the State Forest Departments that look after all Protected Areas (PA), mudflats do not find any mention as if they do not exist. With nearly 7,517 km coastline, including 5,423 km in mainland India, and 2,094 km in the Andaman & Nicobar and Lakshadweep Islands, mudflats are present in almost all coastal states, but if you ask PA Managers, many may have not even heard of them, and even if they know about some mudflats it is generally with a negative attitude, much like most of them have for the so-called 'wasteland'. Actually, most mudflats are listed as wastelands in revenue records. According to the Indian Naval Hydrographic Department's data, the mainland coast consists of 43% sandy beaches, 11% rocky coast including cliffs, and 46% mudflats. There are 61 coastal districts and one-fifth of India's population lives along the coast. Gujarat has the largest coastline in India. While the western coastline of India has a wide continental shelf and is marked by backwaters, large intertidal zones and mudflats, it is the flat east coast of India where the Gangetic, Mahanadi, Godavari, Krishna and Cauvery deltas support huge mudflats.

According to Collins English Dictionary, "mudflats are areas of flat empty land at the coast which are covered by the sea only when the tide is in." Another definition of mudflat is "a low-lying muddy land that is covered at high tide and exposed at low tide". Mudflats are mostly found in areas where the tidal waters flow slowly, such as flat coastline, sheltered bays and estuaries of large rivers. Alluvium from large rivers as they reach the sea, and silt from tidal water intermingle, depositing layers of mud, thus creating mudflats. Some scientists consider the Rann, both the Great (18,000 sq. km) and Little (5,100 sq. km), of Kachchh as the largest mudflats in India, inundated during the monsoon by sea and rainwater.

In areas where the mudflats are deep and stable, and can support vegetation, salt marshes and mangrove swamps are formed – both highly important biologically. It is said that such coastal domain, consisting of mudflats, intertidal zones, salt marshes, and mangroves are the nursery of fish and supply almost 90% of the world's fish catch. Millions of Indian fishermen are dependent on these ecosystems that are mostly considered 'wastelands' in government circles, and are treated as prime areas for reclamation and development. Even well-intentioned initiatives to increase mangrove cover sometimes destroy mudflats, as can be seen in several coastal states of India. In a paper by Samson and Rollon (2008), based on surveys of 70 mangrove restoration sites in the world, it was shown that most of them failed because the sites selected were mudflats, sandbanks or seagrass meadows that could not support mangrove vegetation, as ecologically some of them have not co-evolved to support mangroves. In India also, particularly on Gujarat and Maharashtra coastlines, there is a scramble to plant mangroves. Sometimes the only areas available are open mudflats, which may or may not be suitable for the growth of large trees. The irony is that such misguided attempts damage otherwise healthy coastal mudflats.

The Ministry of Earth Sciences, Government of India, and ICMAM Project Directorate, Chennai, have identified 18 sensitive coastal areas of India, especially for oil spills. Many of these areas are intertidal zones, mangroves, and mudflats. Gulf of Khambat, Gulf of Kachchh, and the mudflats and beaches of Dwarka in Gujarat; extensive mudflats of Sewri and Thane in Mumbai, Gulf of Mannar and Vedaranyam Swamp of Tamil Nadu; Naupada Swamp and mudflats of Andhra Pradesh; Bhitarkanika mangroves, mudflats, and sandy banks around Chilika lake in Orissa, and Sundarbans in West Bengal are some of these sensitive areas. Special mention must be made of the unique mudflat that is the breeding ground of Horseshoe Crab along the Chandipur and Balramgadi coast of Orissa, where during low tide the sea recedes almost 5–6 km to expose one of the widest mudflats on the east coast of India along the Bay of Bengal.

The exposed mudflats, with their rich marine fauna in the form of crabs, fish, algae, polychaetes, molluscs, crustaceans, etc., attract millions of birds. Some of the rarest Indian birds are dependent on mudflats and intertidal zones. For example, the Critically Endangered Spoon-billed Sandpiper *Eurynorhynchus pygmeus* is totally dependent on mudflats for foraging in its winter quarters in India, Bangladesh, and Myanmar. Open mudflats with shallow water and soft mud accumulated in ripples are the ideal habitat of Spoon-billed Sandpiper. The Spoon-billed Sandpiper has a naturally limited breeding range on the Chukotsk peninsula and southwards along the isthmus of the Kamchatka peninsula, in north-eastern Russia. It migrates down the western Pacific coast through Russia, Japan, North Korea, South Korea, mainland China, Hong Kong, and Taiwan, to its main wintering grounds in South and Southeast Asia, where it has been recorded from India, Bangladesh, Myanmar, Thailand, Vietnam, Philippines, peninsular Malaysia, and Singapore (BirdLife International 2001). Perhaps less than one thousand individuals of this tiny migratory bird are left in the world (BirdLife International 2011). In India, it has been reported only from Chilika and Point Calimere, with possibility of its occurrence in Sundarbans (Rahmani, *in prep.*). Another globally threatened bird found in India is Spotted Greenshank *Tringa guttifer*, earlier known as Nordmann's Greenshank, listed as Endangered by BirdLife International (2011) and IUCN that stated "it has a very small population which is declining as a result of the development of coastal wetlands throughout its range, principally for industry, infrastructure projects and aquaculture." It is a rare winter visitor to India with confirmed records only from Point Calimere and a few questionable old records from Assam. Among the Vulnerable category of birds in India, Great Knot *Calidris tenuirostris* is the one that is dependent on mudflats and coastal beaches. It is a rare winter visitor to the east coast of India, with regular sightings from Point Calimere, Pulicat lake and Marine National Park in the Gulf of Mannar, Chilika lake, Bhitarkanika and Sundarbans (Rahmani, *in prep.*). It breeds in Siberia from May to June-July on open, lichen-covered gravelly ground, with stunted bushes and herbs. During migration and in wintering areas, it is usually found in estuaries, coasts, sandy beaches, mudflats, and mangroves. Besides these globally threatened Indian species, there are up to 40 species of common birds that depend totally or partially on mudflats for foraging and resting. Mudflats provide foraging sites for a few gull and tern species when they are inundated. The exposed areas of mudflats are roosting sites for thousands of terns, gulls, and ducks.

Strings of mudflats play an important role as stopover sites for migratory birds to refuel for the long journey to their wintering or breeding destinations. If mudflats are destroyed or degraded/altered for developmental activities, such as construction of ports, fishing harbours, industries, oil exploration, plantations, including mangroves and aquaculture, bird migration is disrupted and eventually the birds die due to lack of energy to continue their quest for their traditional breeding grounds. Therefore, it is not enough to protect just a few mudflats in isolation, such as in Sundarbans and Point Calimere, but we need to protect them all along our coastline. The onus of understanding, documenting, and conserving coastal mudflats in India is not only on the Ministry of Environment and Forests, Government of India, forest departments of maritime states, academics and NGOs, but also the state maritime boards, who jealously own and encompass most mudflats for creating new citadels in the form of ports and harbours and Special Economic Zones. What is needed now is a new assessment of the status of our coastal mudflats by the Chief Naval Hydrographer of India. Would they still be 46%?

Asad R. Rahmani

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Comments by *Prof. B.C. Choudhury and Dr. S. Balachandran*

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SATELLITE TRACKING OF BAR-HEADED GEESE *ANSER INDICUS* WINTERING IN UTTAR PRADESH, INDIA

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In 2010, 4 Bar-headed Geese were captured and fitted with satellite transmitters at Sur Sarovar Bird Sanctuary in Uttar Pradesh, India, to examine their migration and distribution. The individuals fitted with Platform Transmitter Terminal (PTT) 99072, 99073, 99075 and 99076 spent a total of 30 days, 16 days, 36 days and 23 days respectively, in their wintering range after deployment of PTTs. During wintering, Goose 99073 and 99076 ranged within an area of 48.65 sq. km and 124.37 sq. km. However, Goose 99072 and 99075 ranged within an area of 106.76 sq. km and 149.84 sq. km. They migrated towards their breeding grounds between March 25, and April 12, 2010. During their migration, they flew over the Himalaya, a significant barrier to migration for most birds. The Geese equipped with PTT 99072, 99073, 99075 and 99076 covered a total distance of 877 km, 1,005 km, 807 km and 1,305 km respectively. All 4 birds flew to the breeding areas on the Tibetan Plateau, and stayed there for a period of 153-222 days. Three Geese (99072, 99073 and 99076) made a stopover over Xizang province for 1-2 days. However, Goose 99075 directly flew to the breeding ground. Goose 99073 moved within an area of 3,155 sq. km and used three focal areas of 438 sq. km, 457 sq. km and 510 sq. km. Among the four geese, Goose 99076 established itself in the northernmost part. It moved over an area of 10,866.77 sq. km and used two focal areas of 1,168 and 3,368 sq. km size intensively. Goose 99072 moved over an area of 5,263 sq. km and used four focal areas of 75.19 sq. km, 389.9 sq. km, 253.25 sq. km and 236.21 sq. km. Goose 99075 ranged within an area of 13,932 sq. km and intensively moved in three focal areas of 690.18 sq. km, 2,214.68 sq. km and 852.21 sq. km. Geese 99076, 99072, 99075 and 99073 ascended to 5,520, 5,090, 4,790 and 4,920 m above msl respectively, while crossing the Himalaya.

Key words: Bar-headed Geese, Sur Sarovar, migration, distribution

INTRODUCTION

Large numbers of species undertake seasonal migration from their breeding grounds to their wintering grounds each year. This is particularly known in birds, some of which show trans-continental migration involving thousands of kilometres each year. A massive amount of ringing data is collected by many people, including volunteers and professionals. These data help in drawing the distribution boundary of a species and also to track general migration routes. However, satellite tracking helps in identification of precise migration path. It could be linked further to studies on outbreak of avian-borne diseases and migration movement.

As avian influenza emerges and spreads globally, infecting humans along the way, it is necessary to detect an outbreak of the virus as quick as possible. In the last couple of years, several cases have been reported where human beings became infected due to contact with infected birds. So far, 337 cases of human H5N1 have been reported from 59 countries (Williams *et al.* 2008). The main species that serve as reservoirs for spreading viruses are aquatic wild birds, mainly from families of Anseriformes and Charadriiformes such as ducks, geese, swans, gulls, terns and shorebirds (Suarez 2000; Swayne and Suarez 2000). Several authorities, including the more recent Normile (2006), reported that migratory species have the capacity to spread the virus at the time of migration. However, this hypothesis is not accepted universally (Kou *et al.* 2005).

In 2005, avian influenza outbreak was reported from China, at Qinghai lake and the Xinjiang province, and HPAI H5N1 virus was isolated from oropharyngeal and cloacal swabs of carcasses of Bar-headed Geese *Anser indicus*, indicating that H5N1 virus was the cause of death in these birds. The Bar-headed Goose is thus a high-risk species as far as spread of H5N1 is concerned. Therefore, because of these alarming concerns, we selected the Bar-headed Goose for satellite telemetry study during our project "Migratory Movements of Waterbirds through Uttar Pradesh and the Surveillance of Avian Diseases". Migration of Bar-headed Goose across the Himalaya, connectivity of its wintering areas in Keoladeo National Park, Bharatpur, India, and Royal Chitwan National Park, Nepal, and breeding grounds in China and Mongolia have recently been investigated by several scientists by using satellite telemetry (Javed *et al.* 2000; Takekawa *et al.* 2009; Gilbert *et al.* 2011).

The Bar-headed Goose is a species of high altitude wetlands with a global population of <60,000 individuals in the wild (Miyabayashi and Mundkur 1999; Wetlands International 2006; Takekawa *et al.* 2009). Perennou *et al.* (1994) estimated less than 50,000 Bar-headed Goose in the world and the number is probably increasing. The current global population of the species is estimated at *c.* 52,000-60,000 mature individuals and a range (breeding and winter) of 2,370,000 sq. km (BirdLife International 2010). The species is one of the abundant waterbirds, in no immediate danger, and is not on the Threatened list of BirdLife International and IUCN 2010. However, Koppen *et al.* (2010) reported that the population has been adversely affected in recent decades due to unsustainable levels of egg collection, hunting by humans and habitat destruction.

Bar-headed Geese breed on or near large wetlands on high plateaux within a fragmented range from Kyrgyzstan to central China, and as far north as Mongolia (Wurdinger 2005; Takekawa *et al.* 2009; Koppen *et al.* 2010). Bishop *et al.* (1997) reported that more than 25% of the world population winters on the southern Tibetan-Qinghai Plateau. India is a wintering ground for another 25-50% of the population (Javed *et al.* 2000). The total number of breeding pairs in countries, namely Uzbekistan, Tadjikistan and Kyrgyztan will not be more than 150-200 (van der Ven 1997). It is quite common across northern India and the Gangetic Plain (including the Nepal *terai*) to Assam (Ali and Ripley 1987). More than 20,000 individuals of this species have been recorded from a single site, Pong Dam Sanctuary, Himachal Pradesh (Li *et al.* 2009). In Uttar Pradesh, it is found on all large marshes and rivers, especially where some protection is afforded. It has been reported from Sheikha Jheel, Aama Khera and Rati-ka-Nagla, all in Aligarh district, Patna Bird Sanctuary in Etah district, Lakh-Bahosi in Farrukhabad district, Samaspur in Raebareli district, Saman in Mainpuri district, Nawabganj in Unnao district, Narora Reservoir and on the banks of the River Ganga in Bulandshahr and Badaun districts, and numerous other wetlands (Rahmani 1992; Rahmani and Arora 1992; Rahmani and Islam 2008; Rahmani *et al.* 2010). The population has suffered some reduction in numbers due to loss of wetlands in the wintering areas (Foote *et al.* 1996), habitat alteration in portions of their breeding range (Wang *et al.* 2008; Xu *et al.* 2008) and susceptibility to emerging infectious diseases, such as highly pathogenic avian influenza H5N1 (Chen *et al.* 2005; Brown *et al.* 2008). The species is believed to hold a unique physiological feature for flying high (Ward *et al.* 2002; Scott and Milsom 2007; Lee *et al.* 2008).

The possibilities of studying bird migration have increased with the use of satellite tracking. Earlier research work related to bird migration was mainly based on ring recovery data. Satellite tracking offers more detailed information about animal migration routes, wintering ground, home range, behaviour and habitat selection (Seegar *et al.* 1996; Bobek *et al.* 2008). Recently, many birds species such as cranes (Kanai *et al.* 2002), Bar-tailed Godwit (Gill Jr. *et al.* 2008), pelicans (Izhaki *et al.* 2002), raptors (Hake *et al.* 2001), White Stork (Berthold *et al.* 2001, 2002) and Black Stork (Bobek *et al.* 2008) have been satellite-tracked successfully during migration. These methods have provided an easier and faster means of capturing information about migration than ever before. The data available from the Platform Transmitter Terminal (PTT) and radar provide a formidable challenge to understand the spatio-temporal distribution pattern, habitat use and flight locations of migrating birds over large areas.

The focus of our study was to provide information on movement patterns of Bar-headed Goose from Uttar Pradesh, India to the Tibetan Plateau. Our objectives were: 1) Identify areas used as wintering, breeding and stopover sites; 2) Estimate distribution area of each bird at wintering and breeding site; and 3) Determine the time of migration.

STUDY AREA

The floodplain wetlands of the Gangetic Plains of Uttar Pradesh host a multitude of waterfowl each year, both resident and migrant. Bar-headed Geese were captured at Sur Sarovar Bird Sanctuary (27° 00' N; 77° 45' E) near Agra. It is an Important Bird Area (IBA) identified by the Bombay Natural History Society and BirdLife International (Islam and Rahmani 2004) and a potential Ramsar Site (Islam and Rahmani 2008). Sur Sarovar is located on the Agra-Delhi National Highway NH2, about 20 km from Agra, east of the road. It is a water reservoir spread over 7.83 sq. km area, owned by the Irrigation Department of Uttar Pradesh, but now managed by the Forest Department.

The Tibetan Plateau is the highest and largest plateau in Central Asia, covering most of the Tibet Autonomous Region and Qinghai, in addition to smaller portions of western Sichuan, southwestern Gansu, and northern Yunnan in western China and Ladakh in India. It covers an area of 2.5 million sq. km. The Tibetan Plateau has various complex landforms, such as high and steep mountains, deep valleys, glaciers, and bare rocks, with an average elevation of 4,500 above msl.

METHODOLOGY

In 2010, 5 birds were equipped with satellite PTTs at Sur Sarovar Bird Sanctuary and Sheikha Jheel in Uttar Pradesh, India. Of these 4 were Bar-headed Goose and 1 was Gadwall. The PTTs were supported with batteries having a maximum life span of six months. The PTTs were programmed by experts at Telonics Inc. in such a way that they were switched on during the periods when the maximum number of satellites passed over the bird activity areas.

The individual Identification Numbers (IN) of the PTTs, provided by ARGOS France, are mentioned in Table 1. ARGOS PTT Nos. 99072 and 99075 were deployed on two Bar-headed Geese in the Sur Sarovar Bird Sanctuary on March 7 and subsequently two more PTTs, Nos. 99073 and 99076, were fastened to two other individuals of the same species on March 9, 2010, at the same site. One of the five PTTs was fastened to a Gadwall at Sheikha Jheel, an IBA located 20 km away from Aligarh on the Aligarh-Panethi-Jalali road. The Geese as well as Gadwall were captured by a team of professional trappers working with the Bombay Natural History Society (BNHS) using nooses when the birds were about to return to their breeding grounds. The PTTs were attached to the Bar-headed Geese and Gadwall as backpacks using Teflon ribbon harness. The birds were weighed and swabbed orally and cloacally to get samples for investigation of avian influenza, and were also marked with metal rings provided by the BNHS. Each PTT weighed 29 gm, which is *c.* 1% of the total body weight of Bar-headed Goose and 3.5% of the total body weight of Gadwall.

The transmitter signals were intercepted by polar orbit satellites (NOAA) and received at the headquarters of the American-French Company ARGOS. Location data is categorised into different classes such as Z, B, A, 0, 1, 2, 3 to get the measurement of accuracy. It is reported that the system does not calculate the error for Z, B, A due to inadequate reception frequency (Ueta 2000). The data were filtered to exclude the inaccurate points found away from the nearest tracking times and locations. A total of 4,338 locations was obtained and 2,328 of them were used to construct the migration tracks of four individuals. For more information about locations of the tracked geese, see Table 2. The tracks were constructed on the basis of directional movement recorded away from the wintering site. The total length of the tracks was calculated to estimate travel distance between their wintering and breeding grounds.

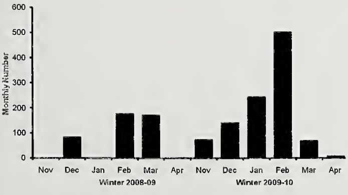

Fig. 1: Population of Bar-headed Geese at Sur Sarovar Bird Sanctuary, Agra, India (November 2008-April 2010)

Maps of migratory routes were generated using the GIS software (ArcGIS and ArcView) with animal movement analysis extensions by one of the authors (MK). Movement areas of each bird in their wintering and breeding grounds were estimated using the minimum convex polygon method.

RESULTS

All marked geese remained in their wintering grounds after they were fitted with the PTTs for a duration ranging from a minimum of 16 to a maximum of 36 days (Table 3). During wintering period at Sur Sarovar the marked geese moved extensively within as well as outside the Sanctuary. The total number of points located within the Sur Sarovar Bird Sanctuary were 13.22%, 5.13% and 4.17% for Geese 99072, 99075 and 99076 respectively. However, Goose 99073 was not located at any point of time within the Sanctuary.

The duration of functioning of ARGOS PTTs was from 6½ months (ID 99072) to nearly nine months (ID 99075) (Table 2). Altogether 4,338 locations were received from CLS ARGOS France for all individuals of Bar-headed Goose fitted with ARGOS transmitters. For analysis, we used 2,328 (54%) locations belonging to 0, 1, 2, 3 categories of location of ARGOS, which have higher accuracy (Table 2). The remaining 46% of location categories (i.e., A, B and Z) which have low accuracy were excluded from data analysis. The total number of locations used in data analysis for the geese with IDs 99072, 99073, 99075, and 99076 were 542, 610, 719 and 457 respectively, for the above-mentioned location classes.

Wintering Areas

During our fortnightly field visits to the Sanctuary in winters of 2008-2009 and 2009-2010, we recorded a maximum of 502 Bar-headed Geese in February 2010 (Fig. 1). As indicated by ground observations and point locations provided by ARGOS, they moved around the Sanctuary extensively, using crop fields and islands of River Yamuna for foraging and resting. During our fortnightly field visits to the Sanctuary we noticed that more than half of the population of Bar-headed Geese would spread out into the

Table 1: Spring migration of four Bar-headed Geese tracked by satellite telemetry from India to Tibetan Plateau

Species (ARGOS ID)	Site (Date of deployment of PTT)	Coordinates	Ring No.	Start of migration (Site)	Arrival at stopver site (DoDSO)	Arrival at breeding ground	Max altitude during flight (in metres)	No. of travelling days between W & B	Total distance* (Avg. distance travelled/day) (in km)	DoMBG & DoAWG
Bar-headed Goose (99072)	Sur Sarovar, Agra (Mar 7, 2010)	27° 34' 60" N 78° 45' 60" E	3906 K	Apr 6, 2010 Catchment of Yamuna	Apr 7 (Apr 14)	Apr 15	5,090	9	877 (97.4)	—
Bar-headed Goose (99075)	Sur Sarovar, Agra (Mar 7, 2010)	27° 34' 60" N 78° 45' 60" E	3907 K	Apr 12, 2010 Catchment of Yamuna	—	Apr 16	4,790	4	1,005 (251.3)	Oct 28 & Nov 2
Bar-headed Goose (99073)	Sur Sarovar, Agra (Mar 9, 2010)	27° 34' 60" N 78° 45' 60" E	3911 K	Mar 25, 2010 Catchment of Yamuna	Mar 27 (Mar 31)	Apr 3	4,920	9	807 (89.7)	—
Bar-headed Goose (99076)	Sur Sarovar, Agra (Mar 9, 2010)	27° 34' 60" N 78° 45' 60" E	3912 K	Apr 1, 2010 Yamuna riverbed	Apr 4 (Apr 12)	Apr 13	5,520	12	1,305 (108.8)	—

* refers to the distance travelled during spring migration

DoDSO=date of departure from stopover site, W=wintering ground, B=breeding ground, DoMBG=date of migration from breeding ground, DoAWG=date of arrival at wintering ground surrounding areas, especially the islands and the catchment area of the River Yamuna flowing close to the Sanctuary. During the day, the geese were also sighted in crop fields, but most would return to the Sanctuary in the evening.

The geese spent a minimum of 16 days (ID 99073) to a maximum of 36 days (ID 99075) in their wintering range after the PTTs were fastened to them (Table 3). The two other individuals remained in their wintering areas for 30 days (ID 99072) and 23 days (ID 99076). The total number of locations received for PTTs from CLS ARGOS for the duration the geese remained in their wintering range was 369, and during this period they ranged from a minimum area of 49 sq. km (ID 99073) to a maximum of 150 sq. km (ID 99075). Geese 99072 and 99076 ranged in an area of 107 and 124 sq. km based on 121 and 72 locations respectively (Table 3 and Figs 3-7). One Bar-headed Goose (ID 99075) went twice around Keoladeo National Park, Bharatpur, but returned to Sur Sarovar in the evening on each occasion (Fig. 7). Goose 99073 travelled a minimum distance of 115.24 km, whereas goose 99075 covered a distance of 404.26 km in its wintering ground (Table 3). Goose 99072 and 99076 travelled 224 and 255 km respectively in their wintering ground before commencing spring migration to their breeding ground.

The overlap area between 99072-99075, 99075-99076, 99072-99073 and 99072-99076 was 25 sq. km, 14 sq. km, 22 sq. km and 1.6 sq. km respectively. However, area overlap among 99072-99073-99075 was 18 sq. km. The maximum overlap area was 31 sq. km shared by the four geese (Fig. 7).

Migratory routes and stopover sites

Bar-headed Geese fitted with PTTs started migrating back to their breeding grounds on March 25, 2010 (ID 99073) and the last (ID 99075) commenced migration on April 12 (Table 1). In the plains of north India, the geese tend to fly 100-200 m above ground but to cross Himalayas, they quickly ascend, sometimes reaching up to 5,600 m above msl (Fig. 2). As revealed by ARGOS locations, all PTT marked Bar-headed Geese started migration from Yamuna riverbed and its catchment area (Figs 3-6) and none from the Sanctuary.

Bar-headed Goose (ID 99073) started migration from the catchment area of the Yamuna on March 25 and reached a stopover site in a remote wilderness area in China in two days. It also halted around water bodies near Badaun, Bareilly and Shahjahanpur areas of Uttar Pradesh (Fig. 8). There were two locations of this individual near Dudhwa National Park on March 26, and it entered Nepal the same day. The bird

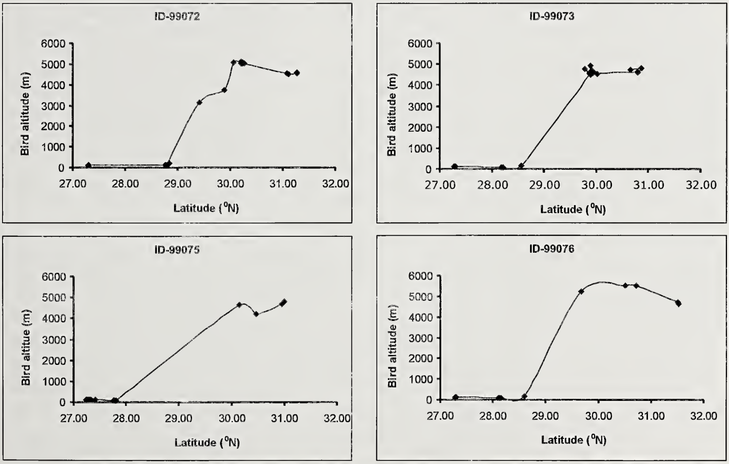

Fig. 2: Relationship between latitude and migration altitude for four satellite equipped Bar-headed Geese

flew up to maximum of 6,087 m above msl before reaching its breeding ground in China. It stayed at a stopover site (29° 53' 20.84" N; 83° 38' 16.32" E) for four days (Table 1) and based on 21 locations, it ranged in an area of 65 sq. km (Table 3). The goose reached its breeding ground in three days, covering a total distance of 807 km during migration (Table 1). The transmitter of this bird stopped functioning on September 20 (Table 2).

The Bar-headed Goose (ID 99076) started migration from the Yamuna riverbed on April 1 (Table 1) and halted near or on water bodies near Badaun, Bareilly, Pilibhit and Shahjahanpur (Fig. 8) for two to three days. The goose reached a stopover site (31° 29' 50.94" N; 83° 07' 48.14" E) in China on April 4 and remained there for 8 days (Table 1). Based on 23 locations, the individual moved within an area of 297 sq. km (Table 3). Among all marked geese, this individual settled in the northernmost area. During migration it crossed the Himalaya at an altitude more than 5,951 m above msl (Fig. 2) and covered the longest distance (1,305 km) among the four geese that were marked by us with ARGOS transmitters. Its transmitter stopped functioning on November 12 (Table 2) while proceeding on its winter migration from China and was last recorded through ARGOS location near China-Nepal border.

The Bar-headed Goose (ID 99072) left its wintering ground from the catchment area of Yamuna (Table 1) on April 6, first heading north-west, later it turned north-east. It used two stopover sites, first in Nepal for a few hours, and departed for the second stopover in China. After leaving Yamuna area, it also stayed around some ponds and water bodies near Badaun, Bareilly, Rampur, Shahjahanpur, Pilibhit and near Dudhwa National Park in Lakhimpur-Kheri before entering Nepal (Fig. 8). There were a few locations (n= 6) in the first stopover site in Nepal where it stayed for less than a day. However, there were 19 locations in the second stopover site (30° 13' 8.06" N; 83° 35' 34.7" E) in Tibet, based on which it was estimated to have moved over 30 sq. km area (Table 3). It reached the second stopover site in China in a day and used this area for seven days (Table 3). The bird flew at more than 5,979 m above msl (Fig. 2), and moved in the Indo-Nepal Himalayan range to reach its breeding ground, covering a total distance of 877 km during migration (Table 1). The transmitter of this bird stopped functioning on September 15, 2010 (Table 2).

The Bar-headed Goose (ID 99075) also commenced migration from the catchment area of River Yamuna. Among the four marked geese, it spent the maximum time (36 days) in its wintering area (Table 3) after the PTT was fixed to it. The bird started migration on April 12 (Table 1) when atmospheric temperature had reached 40 °C. Before flying back to its breeding ground it moved slowly around rivers and water bodies near Badaun, Bareilly and Udham Singh Nagar for 3 days (Fig. 8). From Uttarakhand, the bird entered Nepal near Dhangarhi (30° 27' 1.62" N; 81° 05' 40.79" E) and returned the same day to Uttarakhand state to an area located close to the boundary with Nepal. From Uttarakhand, it flew to its breeding ground at an altitude of 4,790 m above msl (Fig. 2) in the Himalayan range , covering a total distance of 1,005 km during migration. The PTT on this Bar-headed Goose (ID 99075) worked for the longest period of time. The bird started migrating from China on October 28, 2010 and reached Sur Sarovar, the same site it had visited in the winter of 2009-2010 (Fig. 9). It arrived at its wintering ground on November 2, 2010 (03:38 hrs) and was located around Keoladeo National Park, Bharatpur (27.24° N; 77.78° E) at 14:46 hrs on the same day. It covered a total distance of 1,239 km in 5 days while migrating towards its wintering ground. The goose flew above 4,790 m above msl while crossing over the Himalaya (Fig. 2). The PTT of this bird stopped functioning on November 24, 2010 (Table 2).

Table 2: Month-wise number of locations obtained from CLS ARGOS from March 7 to November 24, 2010, indicating different location classes

Bird ID No.	Date of first transmission	Number of Monthly locations									ARGOS Location class							Locations used in analysis	Total locations	Date of last transmission	Duration PTT's functioned
		M	A	M	J	J	A	S	O	N	0	1	2	3	A*	B*	Z*				
99072	7 Mar 2010	116	153	164	128	131	60	4	0	0	237	169	102	34	82	110	22	542	994	15 Sep 2010	193 days
90073	9 Mar 2010	104	136	130	138	132	108	67	0	0	264	247	71	28	94	84	27	610	984	20 Sep 2010	196 days
90075	7 Mar 2010	96	130	126	121	140	118	126	124	73	290	278	112	39	145	153	37	719	1351	24 Nov 2010	263 days
90076	9 Mar 2010	90	112	106	111	98	99	101	11	3	244	141	55	17	114	137	23	457	1009	12 Nov 2010	249 days
Total		406	531	526	498	501	385	298	135	76	1035	835	340	118	435	484	109	2328	4338		

* Locations eliminated from analysis

Breeding areas

CLS ARGOS locations revealed that Bar-headed Goose (ID 99073) arrived first in its breeding ground (Table 1, Fig. 11) in the Tibetan Plateau and moved within an area of 3,155 sq. km (Table 3, Fig. 11). Based on segregation pattern of 508 locations, this individual appeared to use three focal areas (Table 4, Fig. 11) to carry out its daily activities within its breeding area. The first focal area which was used in April, June and August was 509.45 sq. km (based on 56 ARGOS locations) and the second, that was used from April to June and also in September was 438.1 sq. km (based on 248 ARGOS locations) (Table 4). However, the third focal area of activity was 457.22 sq. km (194 locations), located on the edge of a large lake in Tibet, that was used from June 20 to August 18, 2010. This focal area of activity was perhaps used by the goose for breeding. The distance between these focal areas varied from 28 to 53 km (Table 4). The bird remained in its breeding range for nearly six months and its transmitter stopped functioning on September 20, 2010.

The Bar-headed Goose (ID 99076) arrived in its breeding range on April 13, 2010, and established itself in the northernmost part among the four geese (Fig. 13). It moved over an area of 10,866 sq. km based on 344 locations (Table 3). Within the extensive area marked on the basis of locations, it used two focal areas of 1,168 and 3,368 sq. km intensively (Table 4). During spring migration it travelled the maximum distance (1,305 km) among the four geese fitted with PTTs, travelling 109 km per day on an average (Table 1). The transmitter of this goose stopped functioning on November 12, 2010, when it was in its wintering ground.

The third Goose (ID 99072) arrived in its breeding range on April 15, 2010, around Zhari Namco area of the Tibetan Plateau near a large lake (Fig. 10) at 4,830 m above msl. It moved over an extensive area of 5,263 sq. km (based on 379 ARGOS locations) (Table 3) in its breeding range where it could be monitored for more than five months. Based on segregation of 379 locations within its breeding range, there were four focal areas of activity used intensively by the bird (Table 4). One of the four focal areas, used between June 21 and August 14, was 236.21 sq. km (Table 4) and most of the locations within this focal area were on the edge of a large water body, Zhari Namco. The Bar-headed Goose probably bred within this focal area. The last location of the bird in this cluster was on August 22, 2010 when it was still around this lake, possibly with its young ones. The transmitter ceased functioning on September 15, 2010.

Another focal area of activity of the same bird was used from April 15 to May 26, the remaining two from May 17 to 26 and April 15 to June 20. There was a clear overlap of dates among these focal areas of activity, which means that the goose used more than one focal area (cluster of locations) on the same day.

The Bar-headed Goose (ID 99075) was last to migrate from Sur Sarovar and reached an area between Tangra Umco and Zhari Namco in the Tibetan Plateau at 5,179 m above msl, on April 16, 2010. Based on 459 ARGOS locations, this individual ranged within an area of 13,932 sq. km after reaching its breeding ground in Tibet on April 16 and used three focal areas of activity within 95% Minimum Convex Polygon (Table 4, Fig. 12). Among all marked geese, ID 99075 was found to have spent the maximum time (222 days) in its breeding grounds, since the transmitter on this bird remained functional for the maximum period (263 days) (Tables 2, 3). It used one focal area (690.18 sq. km) from April 4 to May 3, 2010. The second focal area (2,214.68 sq. km) was used from May 4 to 27 at the edge of a lake and the goose probably used

Table 3: Winter, stopover and breeding ranges of PTT equipped Bar-headed Geese and the total distance travelled by them

Bird ID	Winter range* (No. of locations)	NoDWR after Deploying PTT's	Stopover range* (No. of locations)	Halt at stopover site	Range in Breeding areas* (No. of locations)	Total distance travelled in Wintering range (km)	Stopover range (km)	No. of days in breeding ground
99072	106.76 (121)	30	30.17 (19)	7 days	5,262.84 (379)	224.11	66.53	153
99073	48.65 (59)	16	65.18 (21)	4 days	3,154.68 (508)	115.24	89.85	170
99075	149.84 (117)	36	-	-	13,932 (459)	404.26	-	222
99076	124.37 (72)	23	297.4 (23)	8 days	10,866.77 (344)	255.23	202.79	213

*areas are in sq. km
NoDWR = No. of days at wintering range

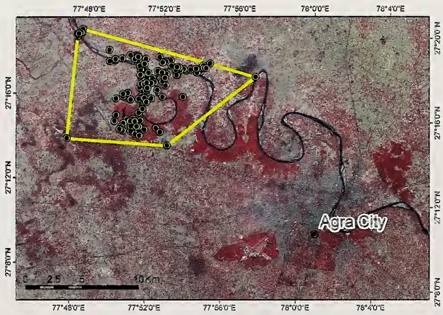
77°48'0"E
77°52'0"E
77°56'0"E
78°0'0"E
78°4'0"E
27°16'0"N
27°12'0"N
27°8'0"N
27°20'0"N
Agra City
0 2.5 5 10Km

Fig. 3: Winter range of the Bar-headed Goose (99072)

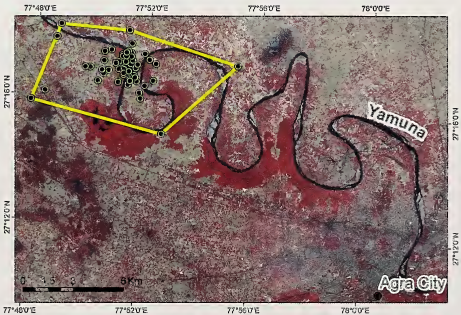
77°48'0"E
77°52'0"E
77°56'0"E
78°0'0"E
27°16'0"N
27°12'0"N
Yamuna
Agra City
0 1.5 3 6Km

Fig. 4: Winter range of the Bar-headed Goose (99073)

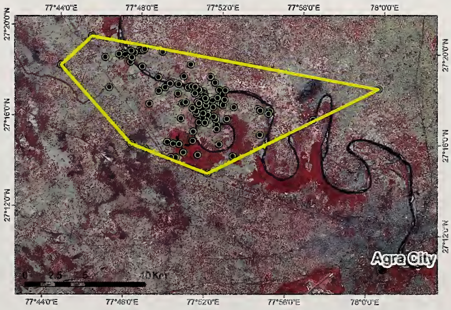
77°44'0"E
77°48'0"E
77°52'0"E
77°56'0"E
78°0'0"E
27°20'0"N
27°16'0"N
27°12'0"N
Agra City
0 2.5 5 10Km

Fig. 5: Winter range of the Bar-headed Goose (99075)

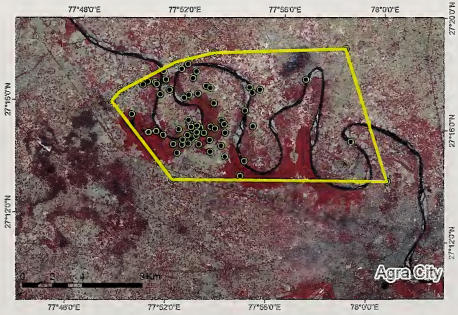
77°48'0"E
77°52'0"E
77°56'0"E
78°0'0"E
27°20'0"N
27°16'0"N
27°12'0"N
Agra City
0 2 4 8Km

Fig. 6: Winter range of the Bar-headed Goose (99076)

● **Winter locations** **Minimum Convex Polygon (95%)**

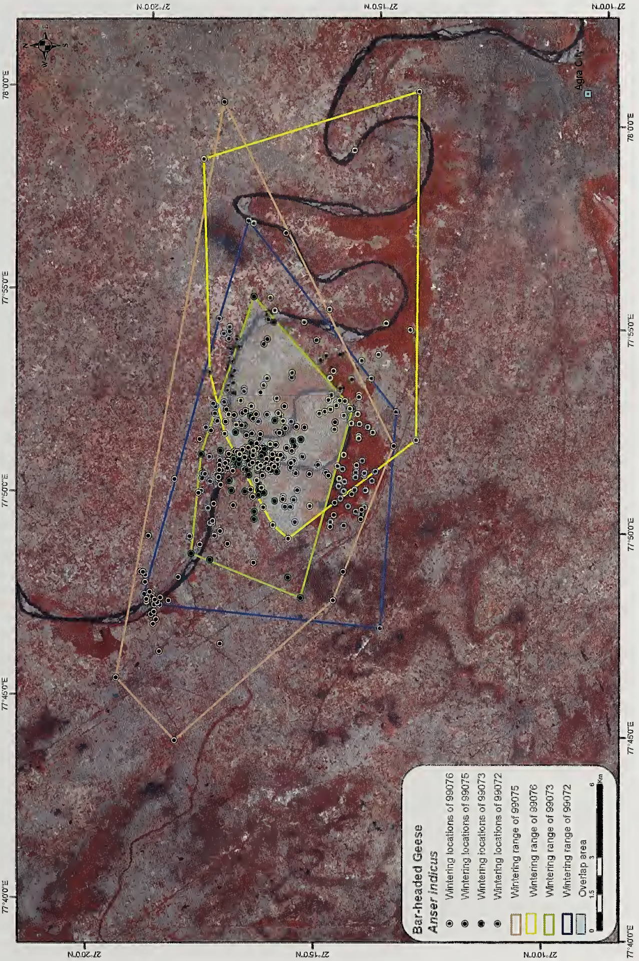
27°20'0"N
27°15'0"N
27°10'0"N
78°0'0"E
77°55'0"E
77°50'0"E
77°45'0"E
77°40'0"E
N
E
S
W
Agra City
Bar-headed Geese
Anser indicus
Wintering locations of 99076
Wintering locations of 99075
Wintering locations of 99073
Wintering locations of 99072
Wintering range of 99075
Wintering range of 99076
Wintering range of 99073
Wintering range of 99072
Overlap area
0
1.5
3
6
Km

Fig. 7: Winter range of four Bar-headed Geese, showing range overlap

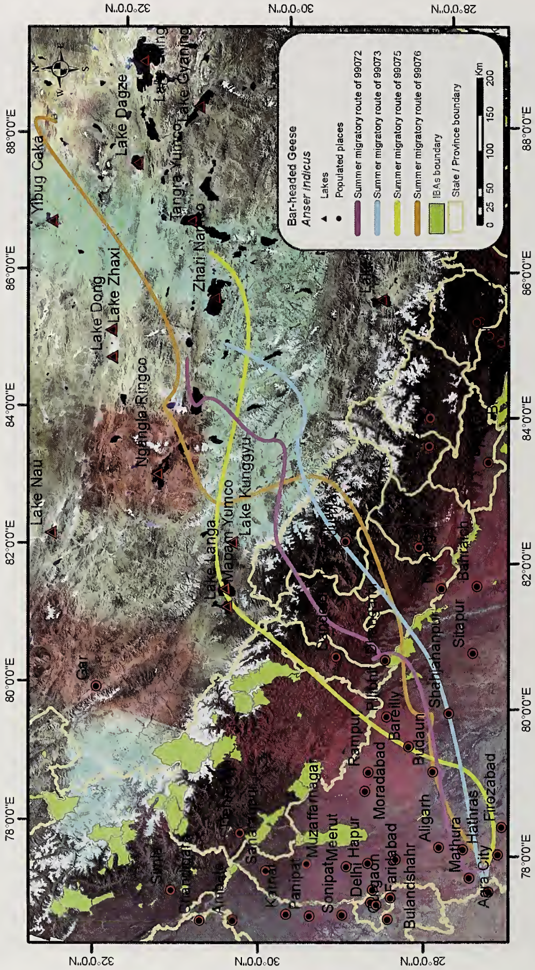
Bar-headed Geese
Anser indicus
▲ Lakes
● Populated places
Summer migratory route of 99072
Summer migratory route of 99073
Summer migratory route of 99075
Summer migratory route of 99076
IBAs boundary
State / Province boundary
0 25 50 100 150 200 Km
32°0'0"N
30°0'0"N
28°0'0"N
78°0'0"E
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
N
E
S
W
Yibug Caka
Lake Dagze
Tangra Yumco
Lake Gyaring
Lake Dong
Lake Zhaxi
Ngangla Ringco
Zhari Namco
Lake Nau
Lake Langa
Mabam Yumco
Lake Kunggyu
Gar
Shimla
Chandigarh
Ambala
Karnal
Panipat
Sonipat
Delhi
Gurgaon
Faridabad
Bulandshahr
Muzaffarnagar
Meerut
Hapur
Moradabad
Rampur
Bareilly
Budaun
Aligarh
Mathura
Hathras
Agra City
Firozabad
Shahjahanpur
Sitapur
Bahraich
Pilibhit

Fig. 8: Migratory routes of four Bar-headed Goose from Uttar Pradesh to Tibet (China)

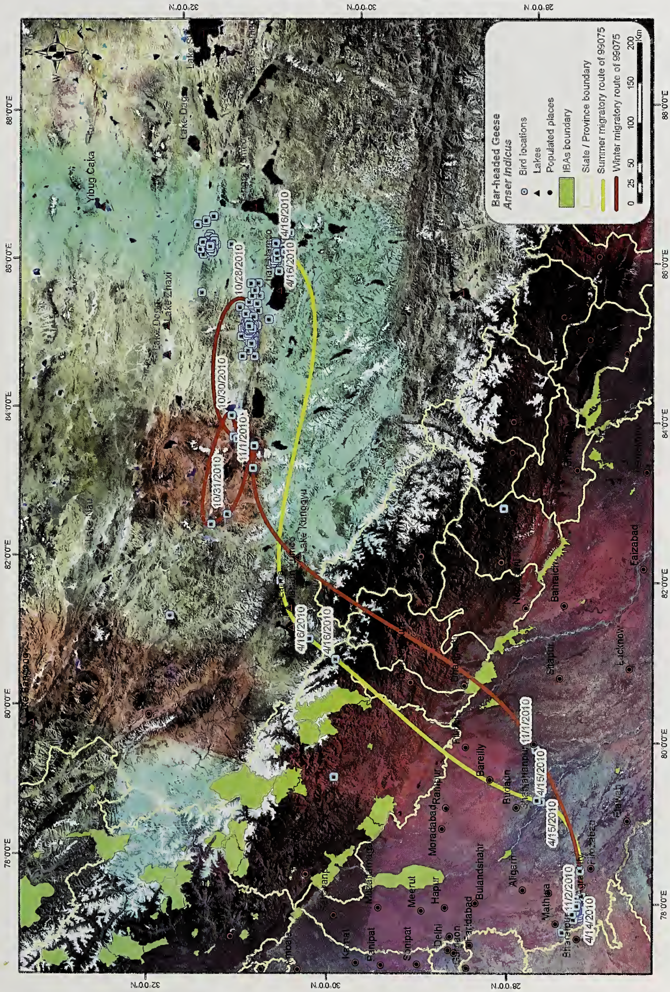
Bar-headed Geese
Anser indicus
Bird locations
Lakes
Populated places
IBAs boundary
State / Province boundary
Summer migratory route of 99075
Winter migratory route of 99075
0 25 50 100 150 200 Km
28°0'0"N
30°0'0"N
32°0'0"N
78°0'0"E
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
Yibug Caka
Lake Dagze
Lake Zhaxi
Lake Dong
Lake Nau
Lake Ranggyu
10/28/2010
10/30/2010
10/31/2010
11/1/2010
4/16/2010
4/16/2010
4/16/2010
4/16/2010
11/1/2010
4/15/2010
4/15/2010
11/2/2010
4/14/2010
Faizabad
Bahraich
Lucknow
Sitapur
Bareilly
Budaun
Shahjahanpur
Moradabad
Rampur
Aligarh
Bulandshahr
Meerut
Hapur
Mathura
Agra
Firozabad
Etawah
Delhi
Sonipat
Panipat
Karnal
Faridabad
Bharatpur

Fig. 9: Spring (yellow) and autumn (red) migratory route of the Bar-headed Goose (99075) from Yamuna catchment (U.P.) to Tibetan Plateau (China) and back

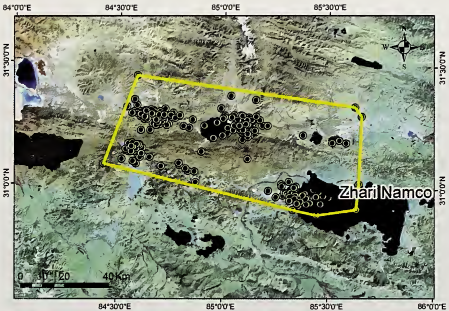
84°0'0"E
84°30'0"E
85°0'0"E
85°30'0"E
86°0'0"E
31°30'0"N
31°0'0"N
Zhari Namco
N
W
E
S
0
10
20
40Km

Fig. 10: Summer range of the Bar-headed Goose (99072)

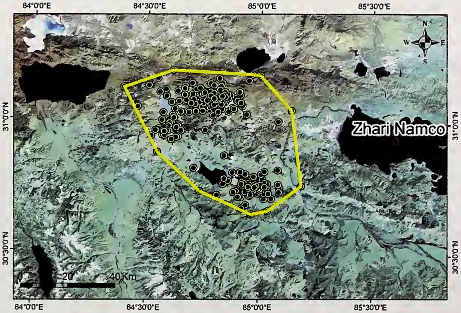
84°0'0"E
84°30'0"E
85°0'0"E
85°30'0"E
31°0'0"N
30°30'0"N
Zhari Namco
N
W
E
S
0
20
40Km

Fig. 11: Summer range of the Bar-headed Goose (99073)

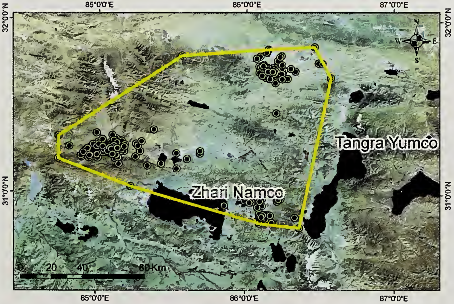
85°0'0"E
86°0'0"E
87°0'0"E
32°0'0"N
31°0'0"N
Tangra Yumco
Zhari Namco
N
W
E
S
0
20
40
80Km

Fig. 12: Summer range of the Bar-headed Goose (99075)

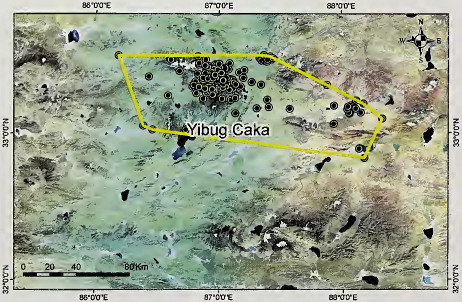
86°0'0"E
87°0'0"E
88°0'0"E
33°0'0"N
32°0'0"N
Yibug Caka
N
W
E
S
0
20
40
80Km

Fig. 13: Summer range of the Bar-headed Goose (99076)

● **Summer locations** **Minimum Convex Polygon (95%)**

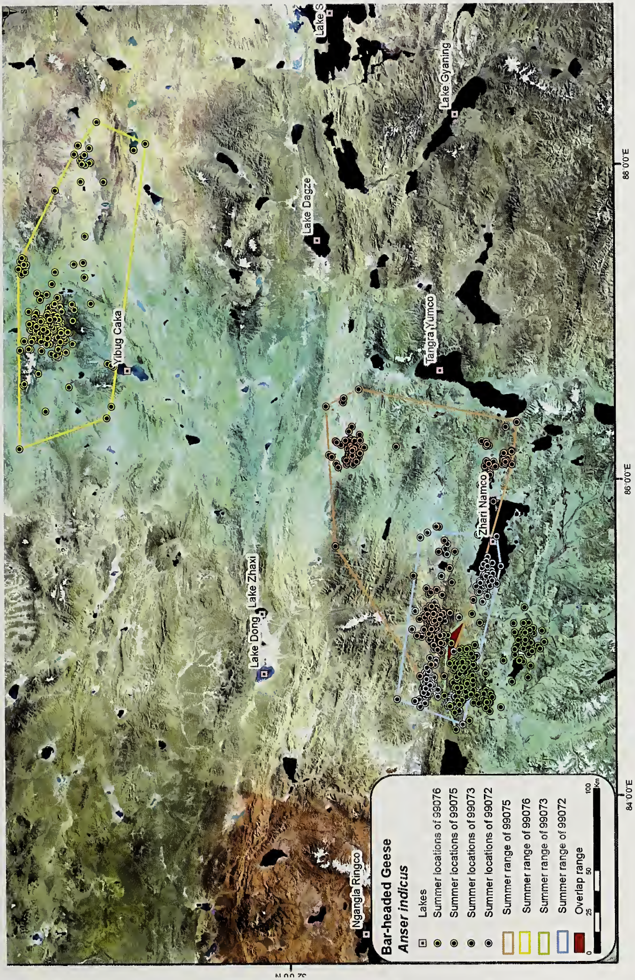
Lake S
Lake Gyaning
Lake Dagze
Yibug Caka
Tangra Yumco
Zhari Namco
Lake Zhaxi
Lake Dong
Ngangla Ringco
Bar-headed Geese
Anser indicus
Lakes
Summer locations of 99076
Summer locations of 99075
Summer locations of 99073
Summer locations of 99072
Summer range of 99075
Summer range of 99076
Summer range of 99073
Summer range of 99072
Overlap range
0 25 50 100 Km
84°0'0"E
86°0'0"E
88°0'0"E
32°0'0"N

Fig. 14: Summer ranges of the four Bar-headed Geese in the Tibetan Plateau showing range overlap

Table 4: Focal areas of use within the breeding range of the geese on Tibetan Plateau

Bird ID	Focal areas of activity in breeding range				Distance between focal areas of activity (in km)				
	Focal area 1 (in sq. km)	Focal area 2 (in sq. km)	Focal area 3 (sq. km)	Focal area 4 (in sq. km)	Focal area 1 & 2	Focal area 2 & 3	Focal area 3 & 1	Focal area 3 & 4	Focal area 4 & 1
99072	75.19	389.9	253.25	236.21	19.48	36.66	49.32	45.95	78.34
99073	509.45	438.1	457.22	-	27.71	41.99	53.09	-	-
99075	690.18	2214.68	852.21	-	96.46	122.58	95.16	-	-
99076	1168.32	3368.11	-	-	100.69	-	-	-	-

it for breeding. Based on spatio-temporal segregation of ARGOS locations, the third focal area of activity (852 21 sq. km, Table 4) was used from August 28 to September 30, when it started moving towards its wintering range in India. This individual returned to its wintering ground on November 2, 2010.

The overlap area between 99075-99072 and 99073-99072 was 2,980 and 996 sq. km respectively. However, the total overlap area among 99075-99072-99073 was only 123 sq. km (Fig. 14).

DISCUSSION

Our study reconfirms that satellite-tracking is effective in studying the migratory movement of birds, and can be used for the identification of unknown migration routes, stopover and breeding sites. Here, we have provided a comprehensive description of migration from its origin, through wintering and breeding season movements of the Bar-headed Goose.

The four geese used the same migration route across India, Nepal and the Tibetan Plateau but their stopover sites differed from each other. We found that all four marked geese flew to breeding grounds located on the Tibetan Plateau. Similar migration routes have been reported for Bar-headed Goose in an earlier study (Javed *et al.* 2000). Geese are well known for flying across the Himalaya (Swan 1970; Javed *et al.* 2000), and adapted for flying at high altitude (Faraci *et al.* 1984, 1985; Ward *et al.* 2002; Scott and Milsom 2007). It has been reported that this species occupies a large range, but the possibility of range destruction is also reported due to global warming, changes in agriculture patterns and loss of wetland habitat at wintering ground.

Previous study on Goose migration reported that the geese captured in the wintering ground of India-Nepal migrated up to a distance of 500-800 km and ascended 4,500 m above msl to reach their breeding ground on the Tibetan Plateau whereas geese captured in China were reported to breed at 3,200 m above msl. However, Geese captured at Mongolia demonstrated leapfrog migration – i.e., they flew over another sub-population migrating from their wintering grounds in the Indian subcontinent to their breeding grounds in Mongolia (Takekawa *et al.* 2009). Our result indicates that geese captured at wintering areas in Uttar Pradesh, India, migrated from 877 to 1,305 km from their wintering areas on the Indian subcontinent to breeding grounds on the Tibetan Plateau and ascended quickly 4,790-5,520 m above msl (Fig. 2).

Koppen *et al.* (2010) reported that the four geese marked in Kyrgyzstan followed different routes leading to their wintering ground in India, Pakistan and Uzbekistan. However, in our study all the four geese captured in a sanctuary followed the same migration route to their breeding ground on the Tibetan Plateau.

Our study demonstrated that the geese also use areas outside Sur Sarovar Sanctuary that are currently unprotected. Therefore, providing protection outside the protected area is necessary for the long-term conservation of the Bar-headed Goose.

More long-term satellite tracking studies of the Bar-headed Goose from its wintering ground to breeding ground would provide the much needed migratory data such as different migratory routes, stopover sites, more specific breeding/summer sites, and threats that these migrants face. More detailed information is necessary also to find out the role of this and other migrant birds in the transmission of bird flu. This two-year study is a pilot effort, and the results suggest the need for further satellite tracking efforts to help expand our basic knowledge and understanding of these long distance migrants.

ACKNOWLEDGEMENTS

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SONNERAT'S SHREW – EVIDENCE FOR A NEW AND POSSIBLY EXTINCT SPECIES IN AN EARLY 19TH CENTURY MANUSCRIPT (MAMMALIA: SORICIDAE)

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Diplomesodon sonnerati described from the excellent diagnosis by Sonnerat in his manuscript *Nouveau voyage aux Indes*.

Key words: Sonnerat, Pondicherry, India, undescribed shrew

Pierre Sonnerat, nephew of the famous French administrator and explorer Pierre Poivre ('Peter Pepper'), was a naturalist, observer of indigenous customs, and himself an administrator in the French colonial empire of the late 18th and early 19th centuries (Ly-Tio-Fane 1976; Deloche and Ly-Tio-Fane 2010). He spent a good deal of time in India in French possessions and outposts (and as a prisoner of the British), and having already published two important books on travel and natural history, had prepared for publication a third manuscript, the *Nouveau voyage aux Indes*, based on his time in southern India from 1786 to 1813. He died in 1814 before it was published, and the manuscript subsequently disappeared until unexpectedly rediscovered in 1978 in the Mitchell Library in Sydney, Australia. The most important parts of the lost book have at last been published (Deloche and Ly-Tio-Fane 2010) in a heavily annotated edition. The text contains general notes on wildlife in various parts of India and also Ceylon (now Sri Lanka), and a small section with dedicated descriptions of animals that Sonnerat believed to be new – including a very distinctive shrew, which has never been recorded since and may be extinct. The other fully described animals are well-known species; in the manuscript they are all rather crudely illustrated with pen sketches, although only one of these is reproduced in the published book. Indian naturalists will recognise the traveller's name in *Gallus sonneratii* Temminck, the Grey Junglefowl.

The shrew and its context

When I visited Mauritius in 2008, the co-author of the new Sonnerat study, Madeleine Ly-Tio-Fane, asked me in 2008 to look over the animal descriptions, and I immediately picked out the shrew as worthy of further investigation. I soon determined that it resembled only one other species. The unusual feature of Sonnerat's shrew is that it was black with a white patch on the back, a feature shared amongst shrews only with the Putorak or Piebald shrew *Diplomesodon pulchellum* (Lichtenstein), known only from Central Asia (Nowak 1999). *D. pulchellum*, however, differs in having a white belly, and not being sexually dimorphic.

Although I had established to my own satisfaction by early 2009 that Sonnerat's shrew was an undescribed species, the *Nouveau voyage* was not the place to publish this, and in any case I wanted to wait until the manuscript was published and accessible. The authors (Deloche and Ly-Tio-Fane 2010) meanwhile were cautious (p. 314, footnote, my translation): "Had he [Sonnerat] found something new? Anthony Cheke remarks that the only known shrew with blackish fur and a white band on the back is *Diplomesodon pulchellum*, an animal distributed in Central Asia (Kazakhstan, Uzbekistan and Turkmenistan). While close, Sonnerat's description does not match in all respects with that of *Diplomesodon*, but all his descriptions in this book lack a certain precision. Could he have received a specimen from Central Asia? Or are we looking at an extinct species, given that he indicates that he found it in fields a few leagues from Pondicherry?"

Sonnerat did not himself travel to Central Asia, and all the other animals described are from the Subcontinent or Ceylon (now Sri Lanka), apart from a parrot that he stated was imported from Penang (Malaysia), and the migratory Red-headed Bunting *Emberiza bruniceps* Brandt that he reported from extralimital Ceylon, but which he probably encountered as a cage-bird. Hence, there is no reason to doubt that he found the shrew, as he claimed, in the vicinity of Pondicherry (now Puducherry).

Species description

The shrew is described by Sonnerat in two passages, one – a general account of wildlife in southern India, the other – a specific diagnosis, accompanied by a crude pen-sketch (Fig. 1). The passages (my translation) are as follows:

From Chapter 4: "On the Indian monsoons; [and] productions of the Coromandel coast", p. 111, after describing the ubiquitous House or Musk shrew *Suncus murinus* (Linnaeus) and its offensive scent:

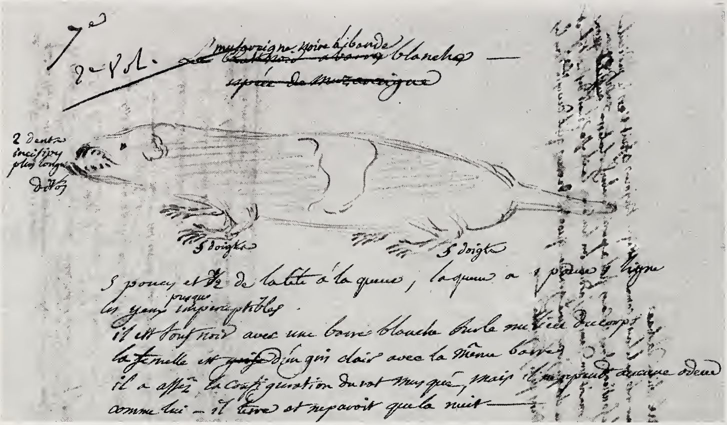
7e
2-V A.
musaraigne noire à bande blanche
~~espèce de musaraigne~~
2 dents incisives plus longues
Dittos
5 doigts
5 doigts
5 pouces et ½ de la tête à la queue, la queue a 1 pouce 1 ligne
les yeux presque imperceptibles.
il est tout noir avec une bande blanche sur le milieu du corps
la femelle est d'un gris clair avec la même bande
il a assez la configuration du rat musqué, mais il ne rend aucune odeur
comme lui – il ne paroit que la nuit –

Fig.1: Sonnerat's sketch, with associated inscriptions, of the "*musaraigne noire à bande blanche*" [black shrew with white band] from his manuscript *Nouveau voyage aux Indes*, held as Item No. PX*D83 p.32 in the Mitchell Library, Melbourne. (Published with permission of the New South Wales State Library. The vertical writing is show-through from the other side of the paper; it has been digitally softened)

"One sometimes encounters with these *rats musqués*[1] a particular species that has all the characters of a shrew, but it does not generate a smell of musk; it is also larger, shiny black with a white band on the middle of the body."

From Chapter 13, "New items relating to natural history", p. 314, Sonnerat's diagnosis:

"This shrew is five and a half inches[2] [149 mm] from the head to the base of the tail; the tail is one inch one line [29 mm] in length; the eyes are almost imperceptible and appear only as two little black points. It is entirely a handsome black, with a transverse white band across the middle of the body; all its fur is silky; the female is smaller and has the same transverse white band, but all that is black in the male is a clear grey in the female.

This shrew has the shape and all the characters of the *rat musqué*, but it never inhabits houses like it does, nor does it give off any musky smell; it is also larger; it stays hidden during the day in holes and only appears at night to seek food; I found it in fields a few leagues[3] from Pondicherry."

The text around the sketch adds '5 toes' written next to both front and rear legs, 'two longer incisor teeth' against the upper jaw, the same against the lower jaw, and the drawing itself shows large down-curved incisors in the upper jaw, all features typical of shrews, i.e., there is no question that Sonnerat's animal was indeed a shrew. The tail is shown as stout and stubby, similar to that of *D. pulchellum*. The rest of the text by the sketch reprises the edited version of the description.

Sonnerat's very adequate diagnosis is, together with his illustration, sufficient to establish this animal as a species new to science which I am naming:

Diplomesodon sonnerati sp. nov.

It is distinguished from all shrews, apart from *D. pulchellum*, by the white dorsal patch, and from *D. pulchellum* by its much larger size, sexual dimorphism, saddle-shaped white patch (not elongated along the back), and dark (not white) underparts.

The generic attribution is tentative, based on the pelage similarity between this animal and *D. pulchellum*. Sonnerat's shrew is, however, twice as long as the Central Asian species (head + body 54-76 mm, Nowak 1999), and if regularly larger than *Suncus murinus*, as Sonnerat claimed, would make it the world's largest shrew. *S. murinus* ranges up to 150 mm in head and body length (Prater 1971; Nowak 1999), making it roughly the same size as Sonnerat's example. Although until now extant *Diplomesodon* was thought to be confined to Central Asia, Pleistocene fossils attributed to the genus, based on dentition, have been found in South Africa (Repenning 1965), suggesting that *pulchellum* (and thus also *sonnerati*) may be a relict of a once widespread radiation.

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[1] The term *'rat musqué'* ['musky rat'] is the name long in use in Mauritius for the house shrew, where Sonnerat will have first encountered it before arriving in India (Cheke 2009).

[2] French inches of 2.71 cm.

[3] A French terrestrial league, 'lieue' = 4.83 km.

Recent DNA analysis (Dubey *et al.* 2008) nests *Diplomesodon* within the large genus *Crocidura*, though the researchers decided, against the usual practice, to "keep this morphologically highly distinctive taxon in its own genus, although this would render *Crocidura* a paraphyletic taxon". Within *Crocidura* it has a very long solitary branch on the phylotree, splitting some 5 million years ago from the rest of Asian *Crocidura*. However, another DNA study (Esselstyn and Brown 2009) found it a mystery sister along its branch labelled 'sp. 4, IN'. Further, investigation showed that this was a shrew collected in 1984 near Araku (near Visakhapatnam) in Andhra Pradesh, eastern India (http://arctos.database.museum/guid/DGR:Mamm:18454), identified as *C. horsfieldii* (Tomes). The tissue material used for DNA study is held in the University of New Mexico, but the skin is in the Carnegie Museum of Natural History in Pittsburgh, USA (catalogue No. CM 92179). However, this specimen is uniformly brown on the back (Suzanne McLaren pers. comm.), and hence is not an example of Sonnerat's shrew. Since other examples of *C. horsfieldii* cluster very differently in the phylotrees (Dubey *et al.* 2008; Esselstyn and Brown 2009), its anomalous DNA linking it to the central Asian *D. pulchellum* suggests an unidentified cryptic species resembling *horsfieldii* living in central-eastern India, which would warrant further research.

DISCUSSION AND CONCLUSIONS

Since no more specimens have emerged since Sonnerat's time, the species may have been very restricted in distribution and since become extinct, perhaps under modern Puducherry's urban sprawl. However, if rare and confined to a small area around Puducherry, it remains possible that the species survives, and so distinctive an animal would be well-worth searching for. Its habitat appears from Sonnerat's description to include agricultural land, so it may be a generalist, however, searching might best be focussed on uncultivated patches, as modern agriculture (pesticides, mechanisation) may have altered the suitability of arable land.

The recent discovery of *Feroculus feroculus* in southern India, previously thought to be confined to Ceylon (now Sri Lanka) (Pradhan *et al.* 1997), and a new, if cryptic, shrew species in Ceylon itself (Meegaskumbura *et al.* 2007) does allow one to hold out hope for the survival of *Diplomesodon sonnerati*. Let the search begin!

ACKNOWLEDGEMENTS

The late Dr. Madeleine Ly-Tio-Fane drew my attention to the animals in Sonnerat's lost manuscript and arranged for a copy of her book to reach me on publication. This eminent Mauritian historian and old friend sadly died on September 21, 2011, while this paper was in press, and I dedicate it to her memory. Jon Dunning (University of New Mexico) and Suzanne McLaren (Carnegie Museum of Natural History) kindly helped with details of the specimen with the anomalous DNA lineage. The Mitchell Library of the State Library of New South Wales, Australia, provided an electronic image of Sonnerat's shrew, and permission to publish it.

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FISH DIVERSITY IN ITHIPUZHA AND MURINJAPUZHA, KERALA, INDIA

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A survey has been conducted on the fishes in Ithipuzha and Murinjapuzha, two tributaries of River Muvattupuzha, Kerala, from October 2009 to May 2010. Cast net, gill net, and scoop nets were used for the study. 69 species of fishes, belonging to 54 genera, 36 families and 13 orders were collected and identified. Fishes belonging to the Order Perciformes dominated the study with 15 families, 20 genera and 25 species, followed by the Order Cypriniformes with 1 family, 6 genera and 14 species. Rare species like *Pristolepis marginata* Jerdon, *Anabas cobojius* (Hamilton-Buchanan), *Butis butis* (Hamilton-Buchanan), *Eleotris fusca* (Forster), *Puntius muvattupuzhaensis* Jameela Beevi and Ramachandran, *Danio malabaricus* (Day), *Pterocryptis wynaadensis* (Day), *Pseudeutropius mitchelli* Günther, *Zenarchopterus striga* (Blyth), *Tetraodon fluviatilis* Hamilton, *Arothron leopardus* (Day) and *Triacanthus biaculeatus* (Bloch) were collected during the study. Presently, these rivers are under severe ecological degradation, due to sand mining and other anthropogenic activities. Despite this, the present study showed rich fish diversity in these rivers, and hence, it is suggested that these rivers be protected to conserve it.

Key words: habitat degradation, sand mining, conservation, anthropogenic activities, threats

INTRODUCTION

Biodiversity studies have gained much attention recently. Icthyofaunal studies were done in different rivers of India (Jayaram *et al.* 1982; Arunachalam and Sankaranarayanan 1999; Sarkar and Banerjee 2000; Bhatt 2003; Mishra *et al.* 2003; Kar *et al.* 2006; Bhakta and Bandyopadhyay 2008; Karmakar *et al.* 2008; Palavai and Davidar 2009; Patra and Datta 2010). The information of diversity from these studies help us understand the need to conserve rare species and prevent exploitation for a sustainable environment. Conservation of fish diversity assumes topmost priority under the changing circumstances of gradual habitat degradation (Kar *et al.* 2006).

The riverine fishery of Kerala is highly diverse and is around 207 species (Gopi 2000). Many species of fishes documented in earlier studies have not been found in recent reports (Ajithkumar *et al.* 2003). Though a number of studies have been conducted on the fish diversity in the rivers of Kerala (Bijukumar and Sushama 2001; Raju Thomas *et al.* 2001; Jameela Beevi and Ramchandran 2002, 2009; Ramachandran *et al.* 2001; NBSAP 2002; Ajithkumar *et al.* 2003; Prasanth Narayanan *et al.* 2005; Raghavan Rajeev *et al.* 2008; Swapna 2009) not much study has been done on the diversity of Ithipuzha and Murinjapuzha. In view of this paucity of information, the present survey was carried out to document the fishes of Ithipuzha and Murinjapuzha.

METHODOLOGY

After preliminary surveys, nine sampling stations were fixed. Collections were made every month from October 2009 to May 2010 using cast, gill, and scoop nets. Samples were also collected from streams and channels opening into various stations, since they are the feeding and breeding grounds of many species. Fishes were preserved in 10% formalin. The morphometric studies were done following Jayaram (1999). Day (1878), Jayaram (1999), Nelson (1984, 2006), and Talwar and Jhingran (1991) were used to identify and classify the collected fishes.

RESULTS AND DISCUSSION

Muvattupuzha river is one of the major rivers in Kerala; it is 123 km long and has a drainage area of 1,554 sq. km. It divides into Ithipuzha and Murinjapuzha at Vettikkattumukku in Ernakulam district, and flows through Kottayam district to join Vaikom lake (Fig. 1). Sixty-nine species of fishes belonging to 54 genera, 36 families and 13 orders were collected. The systematic positions of the collected species are given in Table 1. Order Perciformes showed maximum diversity with 15 families, 20 genera, and 25 species. Order Cypriniformes was second with a single family – Cyprinidae with 6 genera and 14 species. Most of the species collected have ornamental as well as potential commercial value. Puffer fishes like *Carinotetraodon travancoricus* Hora and Nair, *Arothron leopardus* (Day), *Tetraodon fluviatilis* Hamilton and *Triacanthus biaculeatus* (Bloch) were also present in the collection.

According to the local fishermen, many species of fishes, which were abundant in past years, showed a decline in recent catches, due to destruction and degradation of their habitat by ecological and man-made interventions. The recent

Table 1: Systematic position of fishes collected from Ithipuzha and Murinjapuzha river, Kerala

Sl. No.	Scientific Name	Ithipuzha	Murinjapuzha
I.	**Order**: Perciformes		
	A. **Family**: Nandidae		
	Genus: *Pristolepis* Jerdon		
	1 *Pristolepis marginata* Jerdon	+	+
	Genus: *Nandus* Valenciennes		
	2 *Nandus nandus* (Hamilton-Buchanan)	+	+
	B. **Family**: Anabantidae		
	Genus: *Anabas* Cuvier		
	3 *Anabas cobojius* (Hamilton-Buchanan)	-	+
	C. **Family**: Lutjanidae		
	Genus: *Lutjanus* Bloch		
	4 *Lutjanus johnii* (Bloch)	-	+
	5 *Lutjanus argentimaculatus* (Forsskål)	+	+
	D. **Family**: Gobiidae		
	Genus: *Glossogobius* Gill		
	6 *Glossogobius giuris* (Hamilton-Buchanan)	-	+
	Genus: *Awaous* Valenciennes		
	7 *Awaous grammepomus* (Bleeker)	+	+
	Genus: *Stenogobius* Bleeker		
	8 *Stenogobius malabaricus* (Day)	+	+
	E. **Family**: Eleotridae		
	Genus: *Butis* Bleeker		
	9 *Butis butis* (Hamilton)	-	+
	Genus: *Eleotris* Schneider		
	10 *Eleotris fusca* (Forster)	-	+
	F. **Family**: Ambassidae		
	Genus: *Parambassis* Bleeker		
	11 *Parambassis thomassi* (Day)	+	+
	Genus: *Ambassis* Cuvier		
	12 *Ambassis ambassis* (Lacepède)	+	+
	G. **Family**: Gerreidae		
	Genus: *Gerres* Cuvier		
	13 *Gerres filamentosus* Cuvier	+	+
	14 *Gerres poieti* Cuvier	-	+
	H. **Family**: Cichlidae		
	Genus: *Etroplus* Cuvier		
	15 *Etroplus suratensis* (Bloch)	+	+
	16 *Etroplus maculatus* (Bloch)	+	+
	I. **Family**: Channidae		
	Genus: *Channa* Scopoli		
	17 *Channa striata* (Bloch)	+	+
	18 *Channa marulius* (Hamilton-Buchanan)	+	+
	19 *Channa diplogramma* (Day)	+	+
	J. **Family**: Leiognathidae		
	Genus: *Leiognathus* Lacepède		
	20 *Leiognathus equulus* (Forsskål)	-	+
	K. **Family**: Sciaenidae		
	Genus: *Daysciaena* Talwar		
	21 *Daysciaena albida* (Cuvier)	-	+
	L. **Family**: Carangidae		
	Genus: *Caranx* Lacepède		
	22 *Caranx sexfasciatus* Quoy & Gaimard	-	+
	M. **Family**: Scatophagidae		
	Genus: *Scatophagus* Cuvier		
	23 *Scatophagus argus* (Linnaeus)	-	+
	N. **Family**: Sillaginidae		
	Genus: *Sillago* Cuvier		
	24 *Sillago sihama* (Forsskål)	-	+
	O. **Family**: Siganidae		
	Genus: *Siganus* Forsskål		
	25 *Siganus javus* (Linnaeus)	-	+
II.	**Order**: Cypriniformes		
	A. **Family**: Cyprinidae		
	Genus: *Cirrhinus* Cuvier		
	26 *Cirrhinus mrigala* (Hamilton-Buchanan)	+	+
	Genus: *Labeo* Cuvier		
	27 *Labeo dussumieri* (Valenciennes)	+	+
	Genus: *Puntius* Hamilton-Buchanan		
	28 *Puntius mahecola* (Valenciennes)	+	+
	29 *Puntius vittatus* Day	+	+
	30 *Puntius punctatus* Day	+	+
	31 *Puntius filamentosus* (Valenciennes)	+	+
	32 *Puntius parrah* Day	+	+
	33 *Puntius sarana sarana* (Hamilton)	+	+
	34 *Puntius sarana subnasutus* (Valenciennes)	+	+
	35 *Puntius muvattupuzhaensis* Jameela Beevi and Ramachandran	+	+
	Genus: *Rasbora* Bleeker		
	36 *Rasbora daniconius* (Hamilton)	+	+
	Genus: *Amblypharyngodon* Bleeker		
	37 *Amblypharyngodon chakaiensis* Babu & Nair	+	+
	38 *Amblypharyngodon microlepis* (Bleeker)	+	+
	Genus: *Danio* Hamilton-Buchanan		
	39 *Danio malabaricus* (Day)	+	+
III.	**Order**: Siluriformes		
	A. **Family**: Siluridae		
	Genus: *Ompok* Lacepède		
	40 *Ompok malabaricus* (Valenciennes)	+	+
	Genus: *Pterocryptis* (Day)		
	41 *Pterocryptis wynaadensis* (Day)	-	+
	Genus: *Wallago* Bleeker		
	42 *Wallago attu* (Schneider)	+	+
	B. **Family**: Schilbeidae		
	Genus: *Horabagrus* Jayaram		
	43 *Horabagrus brachysoma* (Günther)	+	+
	Genus: *Pseudeutropius* Bleeker		
	44 *Pseudeutropius mitchelli* Günther	-	+
	C. **Family**: Bagridae		
	Genus: *Mystus* Scopoli		
	45 *Mystus oculatus* (Valenciennes)	+	+

Table 1: Systematic position of fishes collected from Ithipuzha and Murinjapuzha river, Kerala (*contd.*)

Sl. No.	Scientific Name	Ithipuzha	Murinjapuzha
	D. **Family**: Ariidae		
	Genus: *Arius* Valenciennes		
46	*Arius subrostratus* Cuvier & Valenciennes	-	+
47	*Arius arius* Day	-	+
	E. **Family**: Clariidae		
	Genus: *Clarius* Scopoli		
48	*Clarius dussumeri dussumieri* Valenciennes	-	+
	F. **Family**: Heteropneustidae		
	Genus: *Heteropneustes* Müller		
49	*Heteropneustes fossilis* (Bloch)	-	+
IV.	**Order**: Elopiformes		
	A. **Family**: Megalopidae		
	Genus: *Megalops* Lacepède		
50	*Megalops cyprinoides* (Broussonet)	+	+
V.	**Order**: Pleuronectiformes		
	A. **Family**: Soleidae		
	Genus: *Synaptura* Cantor		
51	*Brachirus orientalis* (Bloch & Schneider)	+	+
	B. **Family**: Cynoglossidae		
	Genus: *Cynoglossus* Hamilton-Buchanan		
52	*Cynoglossus cynoglossus* (Hamilton)	-	+
VI.	**Order**: Beloniformes		
	A. **Family**: Belonidae		
	Genus: *Xenentodon* Regan		
53	*Xenentodon cancila* (Hamilton)	+	+
	B. **Family**: Hemiramphidae		
	Genus: *Zenarchopterus* Gill		
54	*Zenarchopterus striga* (Blyth)	-	+
	Genus: *Hyporhamphus* Gill		
55	*Hyporhamphus xanthopterus* (Valenciennes)	+	+
VII.	**Order**: Cyprinodontiformes		
	A. **Family**: Aplocheilidae		
	Genus: *Aplocheilus* McClelland		
56	*Aplocheilus lineatus* (Valenciennes)	+	+
57	*Aplocheilus panchax* (Hamilton)	+	+
VIII.	**Order**: Synbranchiformes		
	A. **Family**: Mastacembelidae		
	Genus: *Mastacembelus* Scopoli		
58	*Mastacembelus armatus* (Lacepède)	-	+
	Genus: *Macrognathus* Lacepède		
59	*Macrognathus guentheri* (Day)	-	+
IX.	**Order**: Tetraodontiformes		
	A. **Family**: Tetraodontidae		
	Genus: *Tetraodon* Linnaeus		
60	*Tetraodon fluviatilis* Hamilton	-	+
	Genus: *Carinotetraodon* Benl.		
61	*Carinotetraodon travancoricus* Hora & Nair	+	+
	Genus: *Arothron* Müller		
62	*Arothron leopardus* (Day)	-	+
	A. **Family**: Triacanthidae		
	Genus: *Triacanthus* Cuvier		
63	*Triacanthus biaculeatus* (Bloch)	-	+
X.	**Order**: Anguilliformes		
	A. **Family**: Anguillidae		
	Genus: *Anguilla* Schrank		
64	*Anguilla bengalensis* (Gray)	-	+
XI.	**Order**: Clupeiformes		
	A. **Family**: Engraulidae		
	Genus: *Thryssa* Cuvier		
65	*Thryssa dussumieri* (Valenciennes)	-	+
	Genus: *Stolephorus* Lacepède		
66	*Stolephorus commersonnii* Lacepède	+	+
	B. **Family**: Clupeidae		
	Genus: *Dayella* Talwar & Whitehead		
67	*Dayella malabarica* (Day)	+	-
XII.	**Order**: Mugiliformes		
	A. **Family**: Mugilidae		
	Genus: *Mugil* Linnaeus		
68	*Mugil cephalus* Linnaeus	+	+
XIII.	**Order**: Scorpaeniformes		
	A. **Family**: Platycephalidae		
	Genus: *Cociella* Whitley		
69	*Cociella punctata* Cuvier	-	+

+ indicates the presence of the species; - indicates the absence of the species.

studies of Bhakta and Bandyopadhyay (2008), Raghavan Rajeev *et al.* (2008), Swapna (2009), and Palavai and Davidar (2009) also indicated that habitat loss is the main cause of reduction in fish diversity. Fish diversity and conservation represents a major environmental challenge, at the global level. It will add to existing threats to the species if no immediate policy action is taken against human interventions. A few important management plans that result from this study for the conservation of fish species could be included into the fishery policies of the Government, such as identification and listing of threatened and endangered species, determination of population size and distribution, finding out

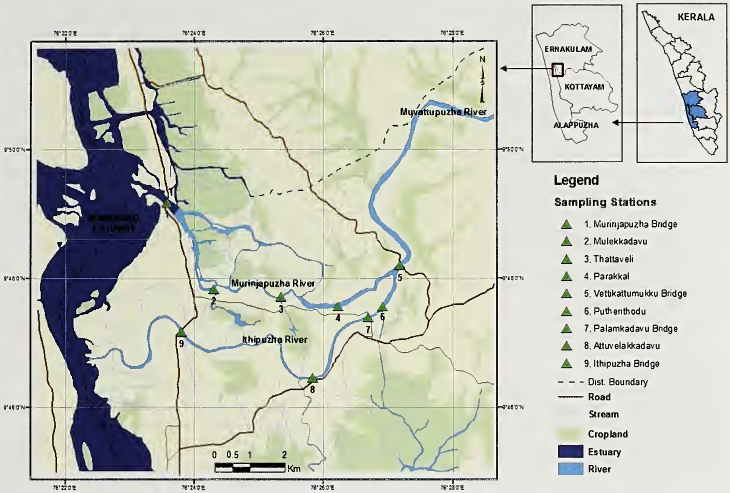
Muvattupuzha River
Murinjapuzha River
Ithipuzha River
N
0 0.5 1 2 Km
ERNAKULAM
KOTTAYAM
ALAPPUZHA
KERALA
Legend
Sampling Stations
1, Murinjapuzha Bridge
2, Mulekkadavu
3, Thattaveli
4, Parakkal
5, Vettikattumukku Bridge
6, Puthenthodu
7, Palamkadavu Bridge
8, Attuvelakkadavu
9, Ithipuzha Bridge
Dist. Boundary
Road
Stream
Cropland
Estuary
River

Fig. 1: Sampling stations in the present study

the breeding behaviour of threatened species, which is essential for both *ex situ* and *in situ* conservation for captive breeding and broodstock maintenance of fishes of potential economic importance (Bhakta and Bandyopadhyay 2008).

From the present study, it is clear that the rivers Ithipuzha and Murinjapuzha are rich in fish diversity. However, these rivers are facing a high degree of threat from sand mining and various anthropogenic activities, and proper management strategies should be implemented to protect and conserve the existing icthyofaunal wealth of our nation.

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STATUS OF REPTILES IN UPPER NILGIRIS, NILGIRI BIOSPHERE RESERVE, WESTERN GHATS, INDIA

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In the present paper, we describe species composition, abundance, richness, diversity and biometry of reptiles inhabiting the Upper Nilgiris (1,800-2,400 m above msl), based on *c.* 27 ha of quadrate and 680 man-hours of visual encounter surveys, between October 2000 and September 2002. Including opportunistic observations, 10 species of reptiles were recorded in the area, which includes seven endemics of the Western Ghats. Species richness, diversity, density and relative abundance of reptiles were low in plantations compared to natural habitats. Richness and Diversity are different, the former is actual number of species observed and the latter is an index. The highest density of 14.85 reptiles/ha was found in grasslands and the lowest in pine forests (4.98/ha). The study shows that most of the species inhabiting Upper Nilgiris were affected by conversion of native vegetation into plantations. This study highlights the conservation importance of both habitat (shola and grasslands) and herpetofauna, as both of them are restricted to the Western Ghats.

Keywords: endemic species, Mukurthi National Park, reptile populations, shola, grasslands, Western Ghats

INTRODUCTION

Herpetofauna tends to be an uncommon subject for field studies, compared to birds and mammals (Vitt 1987). This is mainly due to their relatively small size, cryptic nature, seasonal activity and lack of standard sampling protocols. According to Pearman *et al.* (1995), suitability of many herpetofaunal sampling techniques have not been tested and validated in the tropics. It is speculated that several species, including reptiles, are threatened with extinction due to habitat alterations and fragmentations, and also suspected that many species may become extinct even before proper identification and formal reporting. Theoretical conservation plans without understanding species ecology would not yield desired results (Frazier 1992).

The herpetofauna of southern India is one of the most diverse and ecologically poorly known (Inger *et al.* 1987). The Western Ghats is one of the 34 biodiversity hotspots of the world (Mittermeier *et al.* 2005). Several hydroelectric projects have been implemented in this hill range, and many more are in the planning stage. For instance, there are 36 such projects (24 operational, 12 planning stage) only in the Western Ghats of Kerala (Raj *et al.* 2009). Apart from inundation, these projects have severe impact on biodiversity (Sreekumar and Balakrishnan 1998) due to habitat alterations, hunting and dependency on natural resources by settlers. With impetus given by the (Indian) National Forest Policy-1952, major proportion of the grasslands had been converted into exotic plantations of Black Wattle *Acacia mearnsii*, Eucalyptus *Eucalyptus* spp. and Pine *Callitris rhomboidea*. Impacts of these alterations on wild flora and fauna are poorly understood. Taxa such as herpetofauna could be an ideal model to assess these impacts, as they are specific to certain microhabitats of the area. However, precise data even on the distribution of reptiles of Western Ghats is scanty and the available data are limited to lower and medium altitudes (< 1,200 m; Inger *et al.* 1984; Das and Whitaker 1990; Malhotra and Davis 1991; Zacharias 1997; Ishwar *et al.* 2001). In the present paper, we report the species richness, endemicity, diversity, abundance and biometry of reptiles found in Upper Nilgiris. Notes on the impact of plantations on reptiles with respect to species density are also given.

MATERIAL AND METHODS

Study Area

The present study was conducted in Upper Nilgiris (1,800-2,400 m above msl), especially in and around the Mukurthi National Park (11° 10'-11° 22' N; 76° 26'-76° 38' E) of Nilgiri Biosphere Reserve, Western Ghats. The area of this Park is 78.46 sq. km (Fig. 1), and it has relatively undisturbed grasslands interspersed with shola. The isolated, compact, sharply defined forests between the folds of the hills are known as shola, which consist of stunted evergreen tree species (Puri *et al.* 1990). Champion and Seth (1968) classified this as Southern Montane Wet Temperate Forest. Monthly mean temperature of the Upper Nilgiris during this study varied from 15° to 26° C. Cumulative annual rainfall is about 3,000 mm with peak during July. *Dicanthium polyptychum*, *Chrysopogon zeylanicus*, *Fimbristilis* sp. and *Eriocaulon* sp. are common grass species reported from the area.

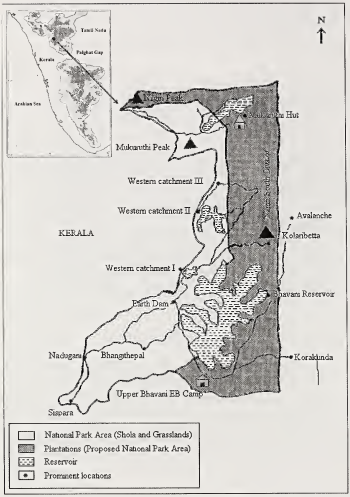
Tamil Nadu
Palghat Gap
Kerala
Arabian Sea
N
Nilgiri Peak
Mukuruthi Hut
Mukuruthi Peak
Western catchment III
Western catchment II
Nilgiri South Division
Avalanche
KERALA
Kolaribetta
Western catchment I
Bhavani Reservoir
Earth Dam
Nadugani
Bhangithepal
Korakunda
Upper Bhavani EB Camp
Sispara
National Park Area (Shola and Grasslands)
Plantations (Proposed National Park Area)
Reservoir
Prominent locations

Fig. 1: Mukurthi National Park and its environs, Upper Nilgiris, Western Ghats

In India, till recently, grasslands have not been viewed as wildlife habitat. An estimated 80% of shola and grasslands have been lost in Upper Nilgiris largely to monoculture plantations (Table 1). Exotic species such as Black Wattle, and Pine were introduced during early 1960s (The Nilgiri District Gazetteer 1995). The Wattle plantations in the area were disturbed due to logging operations, as they were most preferred by tanning industries.

Table 1: Comparative account of habitat loss (in sq. km) in Upper Nilgiris, Western Ghats

Habitat	Year	
	1849	1992
Shola	86.0	42.25
Grassland	298.75	47.00
Cultivation	108.75	124.00
Tea	0	114.75
Wattle	0	97.75
Eucalyptus	0	51.50

Source: website: www.nilgiribiosphereserve.com

Field Methods

A number of herpetofaunal sampling procedures are available in Heyer *et al.* (1994). We used quadrate (10 x 10 m), and visual encounter surveys (VES) for sampling. In both methods, microhabitats, such as boulders, grass clumps, fallen logs and tree trunks, were examined (Campbell and Christman 1982) for reptiles by two personnel. This facilitated effective detection of most of the reptiles, including the hiding ones. Seasonal and opportunistic observations were also made in and around reservoirs. The study was conducted from October 2000 to September 2002, and the fieldwork was largely restricted to sunlight hours (09:00-16:00 hrs) due to the prevailing cold climate. The monthly mean temperature of Upper Nilgiris has been recorded as 15° to 26° C (Nixon 2005), which is much lower than the preferred body temperature of snakes (28-34° C; Lillywhite 1987) and lizards. Night surveys (18:00-21:00 hrs) when ambient temperature was lower conducted prior to intensive data collection (January-April 2000) also did not yield any reptiles. Snout-vent and tail length of the reptiles were taken using a string and metal ruler (accuracy 1 mm) and weighed using a spring balance (accuracy 0.5 gm). Species identification was following Smith (1935, 1943), and the same was confirmed by comparing specimens deposited at the Collection department of the Bombay Natural History Society, Mumbai. Photographs of species observed are deposited at the Sálim Ali Centre for Ornithology and Natural History (SACON), Coimbatore, India. Nomenclature followed herein is of Das (2003).

Data Analysis

The following analyses were done.

1. Number of species observed during the study was considered as species richness.
2. Shannon-Wiener species diversity (H') = $-\Sigma\, p_i \ln p_i$, where, p_i = Proportion of total sample belonging to i^{th} species, ln = Natural logarithm.
3. Hill's diversity (N_1) = $e^{H'}$ where, H' = Species diversity.
4. Encounter rate = No. of individuals sighted/total hours surveyed.
5. Density = No. of individuals sighted/ area sampled.
6. Relative abundance = $(n/N)100$, where n is number of individuals of a species observed, and N is the total number of all species observed.
7. Impact of plantations on the reptile species $(I) = (d_p - d_n)100/d_n$, where d_n = Density of species in shola and grasslands (natural habitat), d_p = Density of species in plantations.

Table 2: Detection of reptiles using quadrate samples in Upper Nilgiris

Habitat	Quadrates examined	Quadrates with reptiles	No. of species observed	No. of individuals	No. of reptiles/ ha
Grassland	840	52 (6.2%)	7	125	14.9
Shola	345	11 (3.2%)	2	51	14.6
Wattle	840	42 (5%)	5	69	8.2
Pine	201	4 (4%)	2	10	6.9
Tea	480	27 (5.6%)	3	27	5.6
Total	2,706	136 (5.03%)	7	282	10.42

RESULTS

A total of 2,706 quadrates (*c.* 27 ha) and 680 man-hours of visual encounter surveys have been conducted in various habitats (shola, grassland, wattle, tea, pine) of the Upper Nilgiris from October 2000 to September 2002. Data from quadrate sampling was used for estimating species density and quantify the impact of habitat alterations on reptiles. Data obtained from both methods were pooled for all other analyses.

Species Richness and Diversity

Including opportunistic observations, 10 species of reptiles have been recorded in Upper Nilgiris (1,800-2,400 m). This includes one species each of Agamid Lizard *Salea horsfieldii*, Day Gecko *Cnemaspis indica* and Skink *Kaestlea bilineata*, and seven species of snakes: *Plectrurus perroteti*, *Xylophis perroteti*, *Ahaetulla perroteti*, *Oligodon venustus*, *Xenochrophis piscator*, *Ptyas mucosa* and *Protobothrops strigatus*. Among them, barring three species, *Protobothrops strigatus*, *Ptyas mucosa* and *X. piscator* all were endemic (70%) to the Western Ghats. The native habitats (shola and grassland) had only seven species, including six (87.5%) endemics. *P. mucosa*, *X. perroteti* and *X. piscator* have not been observed in natural vegetations.

Sampling intensity and detection of reptiles in quadrate and VES are given in Tables 2 and 3. The highest number of species and individuals were observed in VES (8 species, 593 individuals) compared to quadrates (7 species, 282 individuals). In 2,706 quadrates examined in various habitats, on an average only 5% of the quadrates had reptiles; maximum (6.2%) in grasslands and minimum (3.2%) in shola. In 680 hours of VES, the highest detection of 1.87 reptiles/hr was found in grasslands and the lowest (0.38/hr) in Tea plantation (Table 3).

Table 3: Detection of reptiles using visual encounter surveys in Upper Nilgiris

Habitat	No. of hours searched	No. of species observed	Individuals recorded	Reptiles/hr
Grassland	156	6	292	1.87
Shola	230	5	115	0.50
Wattle	144	7	121	0.84
Pine	30	2	19	0.63
Tea	120	4	46	0.38
Total	680	8	593	0.87

Table 4: Reptile species richness and diversity in various habitats of the Upper Nilgiris

Description	Grassland	Shola	Wattle	Pine	Tea
Species richness (N)	7	5	7	2	4
Species diversity (H')	1.24	0.34	1.23	0.21	0.66
Hill's diversity	3.5	1.4	3.4	1.2	1.9

Table 4 provides data on the diversity of reptiles observed in Upper Nilgiris. The highest species richness and diversity was observed in grasslands, whereas pine plantation had the lowest. Among plantations, Black Wattle had the highest species richness and diversity. The Hill's diversity ($e^{H'}$) provides an index of number of contributing species to the diversity or community. Similar to the data of Shannon-Wiener Index, the highest of 3.5 contributing species was found in grasslands followed by wattle, and lowest (1.2) in pine plantation.

Density, Relative Abundance and Biometry

Overall, reptile density was high in the natural habitats (grasslands and shola) compared to plantations (wattle, pine and tea). The highest of 14.85 reptiles/ha was found in grasslands followed by shola (14.6/ha) and the lowest in pine (4.98/ha). Density of lizards was high compared to snakes (Table 5). *S. horsfieldii* had the highest density (13.7/ha) followed by *C. indica* (9.4/ha) in one habitat. Of the eight species observed, five had the highest density in grasslands, two in shola and one in wattle; seven out of eight species had high density in natural habitats compared to plantations.

Relative abundance of reptiles of Upper Nilgiris was calculated based on 875 observations. Relative abundance of *C. indica* was the highest (43.2%) followed by *S. horsfieldii* (36.46%). *X. perroteti* had the lowest relative abundance among all reptiles found in the samples (0.34 %). Abundance of snakes was low compared to lizards (Fig. 2) and among snakes, *A. perroteti* (5.03%) and *P. perroteti* (4%) were relatively high.

Biometry data of eight species of reptiles found in the samples of Upper Nilgiris are given in Table 6. The largest species observed in the area with respect to snout-vent length was *S. horsfieldii* in lizards and *A. perroteti* in snakes, and *C. indica* and *P. perroteti* were the smallest, respectively.

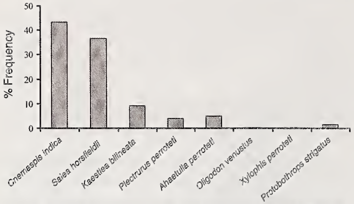

Fig. 2: Relative abundance of reptiles based on 875 observations in Quadrate and Visual Encounter Surveys in Upper Nilgiris, Western Ghats

Snakes were heavier compared to lizards and *X. perroteti* was the heaviest species of reptile observed during this study.

Impact of Habitat Alterations

The natural vegetations, shola and grasslands are contiguous, and most of the grasslands were converted into plantations in the past (Table 1). Hence, data from shola and grassland (natural habitat) and plantations (modified/ altered habitats) were pooled to know the impact of plantations, if any, on reptiles in a broader scale. Of the eight species observed, six had high negative impact (>40%) for plantations. Only two species (*K. bilineata* and *X. perroteti*) had positive values when natural vegetations were altered (Table 7). The present results suggest that most of the species inhabiting Upper Nilgiris were affected by habitat alterations.

DISCUSSION

A total of 120 reptile species have been reported from the Nilgiri Biosphere Reserve (NBR), which includes forest areas from Karnataka, Kerala and Tamil Nadu extending over 5,000 sq. km (Daniels 1993). The Nilgiri District Gazetteer (1995) indicates the occurrence of 86 species in the district. Rich assemblage of reptile fauna in NBR could largely be due to its larger geographical spread, diverse topography (300-2,600 m above msl) and climatic conditions. Apart from smaller area, colder conditions could be one of the major reasons for the poor representation of reptiles (10 species) in the present study area. Similar to the present observations, fewer reptile species have been reported from colder and high altitudes (Rogers 1976; Scott 1976; Heatwole 1982). In colder conditions, the existence of only cold-hardy species is possible. As stated earlier, monthly mean temperature during the study period ranged from 15° to 26° C (Nixon 2005), which is much lower than the optimal body temperature of many species of snakes (28-34° C; Lillywhite 1987). From our observations, ambient temperature appears to be one of the major factors determining the richness of reptiles in higher altitudes.

Ptyas mucosa, *Xylophis perroteti* and *Xenochrophis piscator* have not been observed in natural vegetations, and the former (two) species were observed only in plantations and reservoirs, respectively. *P. mucosa* and *X. piscator* are non-endemics and are relatively common in plains. We presume that *P. mucosa* has reached the high altitudes through plantations. The plantations might have provided ideal habitats for invading rodents (Shanker and Sukumar 1999) that in turn could have formed prey base for *P. mucosa*, which is predominantly a rodent feeder. Invasion of this species to the higher altitudes have also been reported in Sri Lanka (de Silva 1999). *X. piscator* might have reached the Upper Nilgiris through water conducting systems built by the Tamil Nadu Electricity Board. It is not clear as how these species that largely inhabit low hills and plains thrive in colder conditions. Studies on the adaptability of species distributed in colder conditions would provide more insights pertinent to the impact of global warming in relation to species movement from relatively warm lower altitudes to cooler higher altitudes and vice-versa.

Table 5: Density of reptiles in various habitats of the Upper Nilgiris, Western Ghats

Species	Grassland (8.4)	Shola (3.45)	Wattle (8.4)	Pine (2.01)	Tea (4.8)
Cnemaspis indica (Gray, 1846)	9.4	0	2.86	0	0
Salea horsfieldii (Gray, 1845)	1.19	13.7	3.9	4.5	5
Kaestlea bilineata (Gray, 1846)	1.4	0	1.19	0.5	0.42
Plectrurus perroteti (Dumeril, Bibron & Dumeril, 1854)	1.19	0	0	0	0.21
Ahaetulla perroteti (Dumeril, Bibron & Dumeril, 1854)	1.07	0	0.12	0	0
Oligodon venustus (Jerdon, 1853)	0.24	0	0	0	0
Xylophis perroteti (Dumeril, Bibron & Dumeril, 1854)	0	0	0.12	0	0
Protobothrops strigatus (Gray, 1842)	0.36	0.86	0	0	0
Overall density (ha)	14.85	14.6	8.2	4.98	5.6

Data in parentheses indicate area sampled

Table 6: Biometry of reptiles observed in the Upper Nilgiris, Western Ghats

Species	Snout-vent length	Tail length	Weight
Cnemaspis indica (202)	30 ±6	29 ±11	1.6 ±0.65
Salea horsfieldii (310)	549 ±15	120.4 ±43	6.5 ±3.8
Kaestlea bilineata (77)	44 ±11	55 ±21	3.3 ±1.0
Plectrurus perroteti (34)	167 ±53	10 ±4	6.4 ±3.2
Oligodon venustus (3)	272	34	13.5
Xylophis perroteti (6)	288 ±139	37 ±34	19.4 ±18.8
Ahaetulla perroteti (44)	310.2 ±66	109 ±26	18.07 ±8.04
Protobothrops strigatus (12)	244 ±70.4	35 ±8	17.2 ±10.5

± is Standard Deviation; SVL-snout vent length,
tL-tail length in cm and weight (wt) in gram;
Number in parentheses indicates sample size

Table 7: Impact of habitat alterations (natural vegetations to plantations) on the density reptiles in Upper Nilgiris

Scientific name	Natural habitats (d_n)	Plantations (d_p)	Impact (I) (%)
Cnemaspis indica	4.70	1.43	-69.6
Salea horsfieldii	7.45	4.46	-40.1
Kaestlea bilineata	0.71	0.80	+12.7
Plectrurus perroteti	0.6	0.10	-83.3
Xylophis perroteti	0	0.06	+
Oligodon venustus	0.12	0	-100
Ahaetulla perroteti	0.54	0.06	-88.9
Protobothrops strigatus	0.61	0	-100
Overall density	14.7	6.92	-52.9

Heyer *et al.* (1994) suggested using various herpetofaunal sampling methods to maximize the output, however, many of them are largely untested in tropics (Pearman *et al.* 1995). Data obtained using VES and Quadrate differed in quality, number of reptiles/ hour and number of reptiles/ ha. Higher number of species and individuals were observed in VES during this study. It is reported that visual encounter survey is suitable for sampling rare or trap-shy species (Crump and Scott 1994), which is augmented by Doan (2003) and the present study.

Inger (1980) found greater herpetofaunal richness in logged forests and plantations compared to rainforests and suggested that this may be due to environmental factors. In the present study, number of species and diversity was high in grasslands followed by wattle. The wattle plantations found in the study area were logged and the canopy cover was low compared to pine and shola. The Pine plantations had thick canopy cover and the temperature inside was 2-3° C lower at any given point of time (Nixon 2005) compared to grassland and wattle. Information on density, relative abundance and biometry of the reptiles are scanty in India and the present data would form baseline in this regard.

Habitat alterations may have both positive and negative impacts (Vitt *et al.* 1998; Dickerson 2001). In the present study, out of eight species found in the quadrate samples, only *Kaestlea bilineata* and *Xylophis perroteti* got marginal positive impact due to plantation (Table 7). However, species richness, diversity, density, and relative abundance of many species were low in plantations. This study highlights the conservation importance of both habitat (shola and grasslands) and herpetofauna, as both of them are restricted to the Western Ghats.

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NEW RECORDS OF POLYCLAD FLATWORMS (PLATYHELMINTHES: TURBELLARIA) FROM CORAL REEFS OF LAKSHADWEEP ISLAND, INDIA

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Ten new records of polyclad flatworms, which include five species of *Pseudoceros* Lang, 1884, four species of *Pseudobiceros* Faubel, 1984 and one species of genus *Maritigrella*, recorded from Lakshadweep Island, India, are described. One species of genus *Thysanozoon* Grube, 1840 is also recorded.

Keywords: Polyclad, *Pseudoceros*, *Pseudobiceros*, *Maritigrella*, *Thysanozoon*, Lakshadweep, India

INTRODUCTION

Polyclads are prominent among the fauna of coral reefs from tropical and sub-tropical waters (Bolaños *et al.* 2007). Other than coral reefs, polyclads often inhabit rocky intertidal crevices, in association with other invertebrates (Quiroga *et al.* 2004). Although conspicuous, data available on taxonomy and geographical distribution of polyclads is scanty, and mostly concentrated to a particular region.

The earlier works on polyclad worms are by Lang (1884), Woodworth (1898), Haswell (1907), Yeri and Kaburaki (1918), Kaburaki (1923a, b) and Bresslau (1933). Marcus (1950), Hyman (1939, 1954a,b, 1955, 1959) and Prudhoe (1985, 1989) also have important contributions in polyclad taxonomy. Faubel (1983, 1984) used the reproductive anatomy to classify polyclads. The most intensive work on polyclad diversity, from the Indo-Pacific region, was by (Newman and Cannon (1994, 1995, 1996a,b, 1997, 1998, 2000), Newman and Anderson (1997), Newman and Peter (2002), Newman *et al.* (2003). Some literature is also available from the Persian Gulf (Zahra *et al.* 2009).

In India, studies on polyclads have remained neglected; little is known about their diversity on the east and west coasts. Laidlaw (1902) studied six species of *Pseudoceros* and one species of *Thysanozoon* from the Maldives and Laccadive archipelagos. This paper describes ten species of polyclads of Family Pseudocerotidae Lang 1884 and one species of Euryleptidae Lang 1884, from Lakshadweep Island, India. All the species are new to the Indian coast, except *Thysanozoon* of Family Pseudocerotidae (Laidlaw 1902).

STUDY AREA

Field collections were conducted on Kavratti island, Lakshadweep, west coast of India, from December 2008 to March 2009, on the eastern reef and shallow lagoon west of the island. The habitat on the eastern reef is dominantly coral boulders and loose rocks, while the lagoon is dominated by a coral reef. Direct search method was used; specimens were hand collected, during low tides in the intertidal region by over-turning rocks, besides snorkeling in shallow waters. Geographical details were taken at collection sites and a position has been mapped with the Google Earth images. Live specimens were photographed *in situ* to record the true colours. Description of the colour patterns is based on live specimens. Identification is purely on the basis of external morphology and colour patterns with the aid of above mentioned literature and online databases (Discover Life; Authour-Wolfgang Seifurth (1997); Newman and Cannon (2003)).

Descriptions

Family: Pseudocerotidae

Pseudoceros goslineri Newman & Cannon, 1994

Description: Body is elongated and oval with a few marginal ruffles. Pseudotentacles are simple tubular folds of anterior margin. Dorsal surface is creamish with orange, pink and brick-red dots, spread unevenly. Reddish spots clustered together, appear as irregular blotches near the anterior extremity and just behind the cerebral eyespot. Dorsal margin has pinkish-purple irregular spots, which are closer across the pseudotentacles.

Size: 20 mm.

Extralimital Distribution: Indo-Pacific.

Pseudoceros indicus Newman & Schupp, 2002

Description: Body is elongated with a few marginal ruffles. Pseudotentacles are simple and erected. Dorsal surface is opaque, white to creamish with ink blue or purple well-defined spots along the margin. These spots are irregular in shape, well spaced-out and continue over the pseudotentacles. The mid-dorsal area has a pink tinge in some specimens. The species shows a wide range of colour variation.

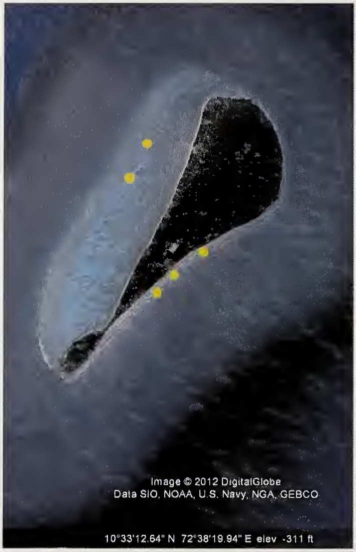
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Fig 1. Map of Kavaratti Island indicating the collection sites

Size: 20 mm.

Extralimital Distribution: Indo-Pacific.

Pseudoceros paralaticlavus Newman & Cannon, 1994

Description: Body is elongated with well-defined marginal ruffles and simple pseudotentacles. Dorsal surface is black, with a wide median greyish band whereas margin shows two distinct bands, inner white and outer bright yellow. Pseudotentacles are black with a yellow margin.

Size: 40 mm.

Extralimital Distribution: Indo-Pacific.

Pseudoceros prudhoei Newman & Cannon, 1994

Description: Body is elongated with shallow marginal ruffling and simple pseudotentacles. Dorsal surface is deep brown to black with two marginal bands; the inner band is blue and outer yellow.

Size: 30 mm.

Extralimital Distribution: Indo-Pacific.

Pseudoceros* cf *susanae Newman & Anderson, 1997

Description: Body is elongated with a few marginal ruffling. Pseudotentacles are simple, pointed and erect; they are blue with a dark purple rim. Dorsal surface is bright orange with a white stripe at the mid-dorsal region and margin shows a white band at the centre followed with a dark purple band.

Size: 60 mm.

Extralimital distribution: Indian Ocean.

Pseudobiceros gratus Kato, 1937

Description: Body is elongated with deep marginal ruffles. Pseudotentacles are erect, pointed and ear-like. Dorsal surface is white with parallel black stripes. Mid-lateral stripes meet at both extremities. Lateral stripes do not extend beyond cerebral eyespot, but meet posteriorly. Body has a thin black margin, which also runs across the pseudotentacles.

Size: 40 mm.

Extralimital Distribution: Indo-Pacific.

Pseudobiceros murinus Newman & Cannon, 1997

Description: Body is transparent, grey-green with a few marginal ruffles. Pseudotentacles are long, erect and pointed. Pseudotentacles are purple-pink with a white spot at the tip. Dorsal surface with irregular black and white dots in evenly spread scattered clusters. Median portion is raised and reddish whereas margin shows an orange band with a narrow white rim.

Size: 60 mm.

Extralimital Distribution: Indo-Pacific.

Pseudobiceros stellae Newman & Cannon, 1994

Description: Body is elongated with deep marginal ruffles. Pseudotentacles are square and inflated. Dorsal background is black with white dots throughout. Larger dots appear like clusters and are distributed regularly.

Size: 30 mm.

Extralimital Distribution: Indo-Pacific.

Pseudobiceros uniarborensis Newman & Cannon, 1994

Description: Dorsal surface is dark brown to black with margin having three distinct bands – inner bright orange, middle transparent grey and outer opaque white. Pseudotentacles are pointed and black with white tips and without marginal bands.

Size: 25 mm.

Extralimital Distribution: Indo-Pacific.

***Thysanozoon* sp.**

Description: Body is translucent and elongated, with a few marginal ruffling. Pseudotentacles are small. Dorsal surface

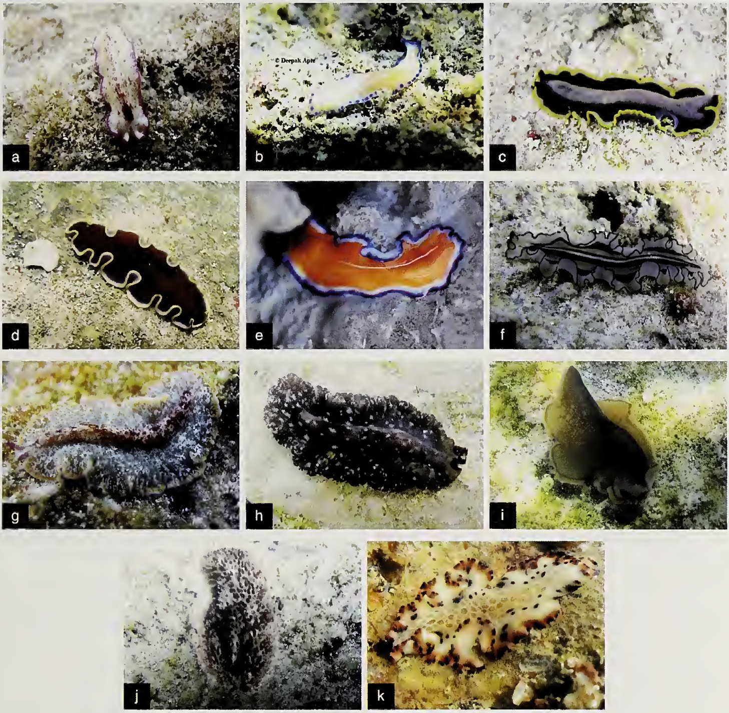

Fig. 1 (a-k): Polyclad flatworms recorded from coral reefs of Kavaratti Island, Lakshadweep Islands, a. *Pseudoceros goslineri*; b. *Pseudoceros indicus*; c. *Pseudoceros paralaticlavus*; d. *Pseudoceros prudhoei*; e. *Pseudoceros* cf *susanae*; f. *Pseudobiceros gratus*; g. *Pseudobiceros murinus*; h. *Pseudobiceros stellae*; i. *Pseudobiceros uniarborensis*; j. *Thysanozoon* sp.; k. *Maritigrella fuscopunctata*

shows pink-white mottling and numerous red-brown papillae.

Size: 20 mm.

Extralimital Distribution: Indo-Pacific.

Family: Euryleptidae

Maritigrella fuscopunctata Newman & Cannon, 2000

Description: Body is elongated with deep marginal ruffles. Marginal tentacles are pointed and erect. Dorsal background is creamish white, with black spots in transverse rows. Black spots are surrounded by a faint violet band. The mid-dorsal portion is raised with orange spots, which are arranged in a honeycomb pattern. Margin shows orange band and small black spots extending across the tentacles.

Size: 40 mm.

Extralimital Distribution: Indo-Pacific.

CONCLUSION

Among the eleven species of polyclads recorded in Kavaratti Island of Lakshadweep, *Pseudoceros indicus*, *P. paralaticlavus*, *P. prudhoei* and *Pseudobiceros murinus* were common. *Pseudobiceros gratus* and *Maritigrella fuscopunctata* were rare. The records of these polyclad species in the Lakshadweep Islands, which have hitherto not been reported from the Indian coasts, clearly reveal the major gaps in the documentation of polyclad fauna of India. More surveys and studies need to be taken up to document the polyclad fauna of India. There will also be a need for DNA sequencing to reveal the actual diversity of this confusing group.

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CHANGES IN THE NUMBER OF BREEDING PAIRS, NEST DISTRIBUTION AND NESTING TREES USED BY THE LAPPET-FACED VULTURE *TORGOS TRACHELIOTUS* IN THE MAHAZAT AS-SAYD PROTECTED AREA, SAUDI ARABIA

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From 1992 to 2003, the number of Lappet-faced Vulture *Torgos tracheliotus* pairs nesting in Saudi Arabia's Mahazat as-Sayd Protected Area, which was established in 1989, increased from 6 to 37. The distribution of nests concentrated in two small core areas in the east and south-east (1992 and 1995) changed to a more even pattern across the protected area (2003). Concomitantly, the tree species used for nesting changed from being almost exclusively *Maerua crassifolia* (1992-1998) to *Acacia tortilis*. The fence around the protected area reduces disturbance, which is a factor affecting the breeding success of these vultures; the increase in the number and distribution of nests is probably a response to effective protection of the area. Changes in nest-tree species probably reflect their general availability, as *Acacia tortilis* is the dominant species in Mahazat, whereas *Maerua crassifolia* is concentrated in the reserves' eastern part.

Key words: vultures, breeding success, Mahazat, protected area, *Maerua crassifolia*, *Acacia tortilis*, *Torgos tracheliotus*

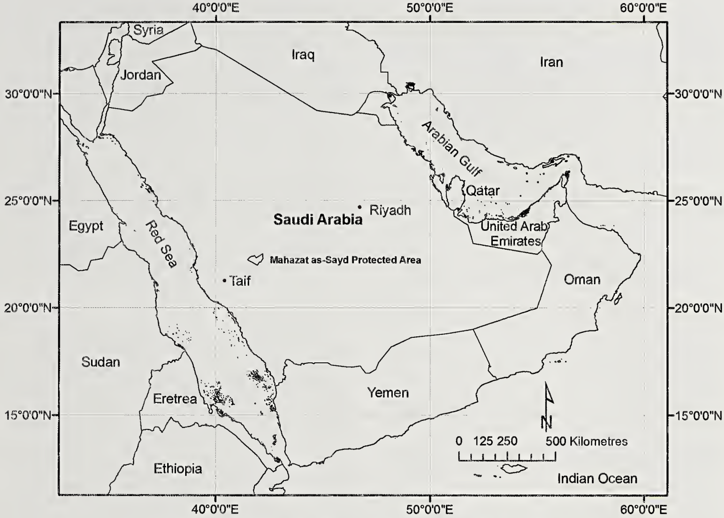
INTRODUCTION

Among the old world vultures, the Lappet-faced Vulture *Torgos tracheliotus* is one of the most poorly studied species and little detailed work has been done on its breeding biology in Arabia, where it is represented by the subspecies *T.t. negevensis* (Jennings and Fryer 1984; Newton and Shobrak 1993). The first information on its breeding biology was published by Newton and Newton (1996), and recently Shobrak (2004) published detailed information on the parental investment made by adult Lappet-faced Vultures during the breeding season in the Mahazat as-Sayd Protected Area in Saudi Arabia.

Populations of the other two subspecies – *T.t. tracheliotus* and *T.t. nubicus* – have been shrinking in numbers and range in Africa (Mundy *et al.* 1992); globally, the Lappet-faced Vulture *Torgos tracheliotus* is considered threatened, with IUCN status Vulnerable; its small population is declining owing to poisoning and persecution (Shobrak 2003; BirdLife International 2007, 2008). Nevertheless, according to Jennings (2010), there are probably 600 breeding pairs of *T. tracheliotus negevensis* in the Arabian Peninsula. Indeed, the species is almost common in the plains of west-central Saudi Arabia, 19° N (Newton and Shobrak 1993; Shobrak 2003). Oman has a small breeding population (Gallagher 1982), numbers in eastern Yemen are unknown (Jennings 2010), and breeding populations no longer exist in Israel, Jordan and the United Arab Emirates (Leshem 1984; Khoury 2000; Cunningham 2002). Thus, based on the number of nests recorded in different parts of Saudi Arabia, the Kingdom probably hosts the only viable population of the subspecies *negevensis* in the Middle East (Shobrak 2003). Accordingly, the present work was aimed at studying the changes in the number of breeding pairs, nest distribution and nesting trees utilized by the Lappet-faced Vulture *Torgos tracheliotus* in the Mahazat as-Sayd Protected Area, Saudi Arabia, between 1992-2003.

STUDY AREA AND METHODS

The Mahazat as-Sayd Protected Area (hereafter 'Mahazat' or 'the Reserve') is a 2,245 sq. km fenced area located on the arid plains of western Saudi Arabia, 170 km north-east of Taif (Fig. 1). It has been protected since 1989 mainly as a reintroduction site in Saudi Arabia for the Arabian Oryx *Oryx leucoryx*, Arabian Sand Gazelle *Gazella subgutturosa marica*, Macqueen's Bustard *Chlamydotis macqueenii* and Common Ostrich *Struthio camelus* (Greth and Schwede 1993; Haque and Smith 1994, 1996). The English name of the birds species are from Gill and Wright (2006), whereas the scientific names are quoted from Dickinson (2003). The English and scientific names for the mammals species were quoted from the IUCN SSC Antelope Specialist Group (2008). Owing to the perimeter fence, Bedouins and their livestock have no access to the Reserve. The majority of the substrate in the Reserve is open sandy gravel. The climate is tropical and arid; mean monthly minimum and maximum ambient temperatures are 9-25 °C respectively in winter and 21-46 °C in summer. Rainfall about 15-240 mm annually occurs between March and May (Shobrak 2001). *Acacia tortilis* is the most common shrub or tree species in the area, *Fagonia indica* and *Indigofera spinosa* are the most common herbs, and *Panicum turgidum* and *Stipagrostis* spp. are the most common grasses (Shobrak 2004).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Mahazat as-Sayd Protected Area
Taif
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Indian Ocean

Fig. 1: Map showing the location of the Mahazat as-Sayd Protected Area

Lappet-faced Vulture nests were counted in the Mahazat from 1992 to 2003. Nests without eggs were excluded and only active nests were used in this study. Data from 1992 to 1995 on nesting sites in the Reserve have been published elsewhere (Newton and Newton 1996; Shobrak 1996). In 1996 no data were available, and in 1997 in my absence the nests were counted by rangers, who missed certain information on locations, so data on inter-nest distances were not recorded. Nest sites were located through either ground or aerial surveys, or from information received by other researchers and rangers working in the area. Outside the Reserve, nests were identified during aerial surveys in 1993, 1998 and 2003 to locate and count the livestock in the 20 km belt around the perimeter fence. Ground surveys to locate nests outside the Reserve were carried out once or twice in a year. Within the Reserve, ground surveys were carried out 1-3 times a month during the breeding season (December-June), as some nests could only be detected when the chick was two months old and standing up. Nest locations were recorded with GPS units. Inter-nest distances were calculated using ArcView 3.1 software for nests located between 1998 and 2003.

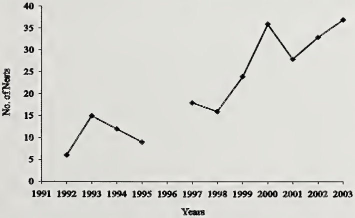

Fig. 2: Number of Lappet-faced Vulture nests recorded in the Mahazat as-Sayd Protected Area from 1992 to 2003

RESULTS

The number of Lappet-faced Vulture nests in the Reserve increased from 6 in 1992 to 37 in 2003 (Fig. 2). The maximum number of active nests located in the Reserve

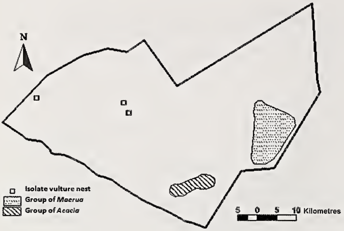

Fig. 3: The distribution of Lappet-faced Vulture nests in the Mahazat as-Sayd Protected Area from 1992 to1995

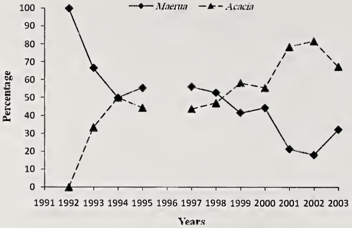

Fig. 5: The proportion of annual variation in two tree species used by nesting Lappet-faced Vultures in the Mahazat as-Sayd Protected Area

during the monitoring period was 37 in 2003, with a mean distance of 3.11 ±1.61 km between nests. Changes in the distribution of nests and the nesting trees were also recorded (Figs 2 and 3). Between 1992 and 1995 the nests were found either in one of two core nesting areas or on isolated single trees (Newton and Newton 1996; Shobrak 1996). The first (eastern) core area contained the largest number of nests, all on *Maerua crassifolia* trees (30 nests within 40 sq. km), with an average height for nests of 4.6 ±0.87 m. The second (southern) core area consisted of eight nests, all on *Acacia tortilis* trees within an area of 5 sq. km, with an average height for nests of 3.7 ±0.52 m. The isolated nests away from the two core areas were all on *Acacia tortilis* trees (Fig. 3, Newton and Newton 1996). However, from 1998 to 2003 the distribution of nests in the reserve changed as nests became more widespread, with a mean inter-nest distance of 3.90 ±1.61 km, n = 174 (Fig. 4).

Lappet-faced Vulture nests have a bulky structure, and are often visible from a considerable distance on the *Maerua* trees, but those in *Acacia tortilis* can be well-hidden in the canopy (Newton and Shobrak 1993). The number of nests on *Acacia* trees increased over 12 years, while the number of nests on *Maerua* trees decreased (Fig. 5). In addition, between 1998-2003 there was a significant difference in the distance between nests in different years ($F_{5,106}$= 3.9, P<0.003) and also within the same species of nesting trees (*Acacia vs Acacia*, $F_{4,77}$= 2.88, p<0.028; *Maerua vs Maerua*, $F_{4,35}$= 6.17, P<0.001) (Fig. 6). Moreover, comparing the height of nests used by Lappet-faced Vultures there is no significant difference between nests occurring in *Maerua* and *Acacia* during 1992-1995 and 1998-2003 (1992-1995, t-*test* t_{33}=3.8, P<0.001; 1998-2003, t-*test*, t_{42}= -2.30, P<0.027). In addition, the distance between some active nests was as short as 1.4 km in the last three years of the study, whereas within the core areas,

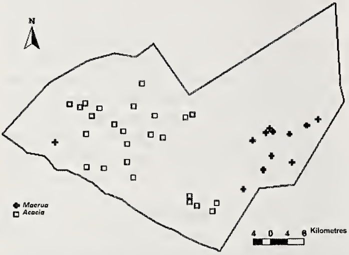

Fig. 4: The distribution of Lappet-faced Vulture nests in the Mahazat as-Sayd Protected Area in 2003

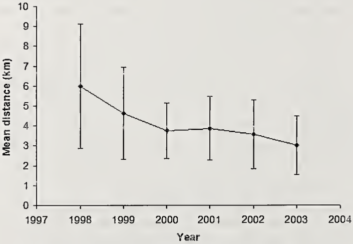

Fig. 6: The mean distance between nests located between 1998 and 2003

nest of adjacent pairs were fairly evenly spaced, nearly always greater than 2 km apart.

As nesting pairs are not marked, re-use of nests by the same pairs was difficult to determine. However, it was presumed that a nest established near the previous year's nest belonged to the same pair. Out of 174 nests found over the lifetime of the study, 121 were new.

Only two nests were found outside the Reserve, one in 1993 to the north-east and the other in 1999 on a *Maerua* tree. The 1993 nest was recorded during an aerial survey and subsequently found to hold a 40-50 day old chick. Five non-active nests, all in *Maerua* trees, had large stones in them. In 1994, no active nests were found outside the Reserve, and the 1993 nest-site had been abandoned.

DISCUSSION

Newton and Newton (1996) showed that the availability of suitable nest-trees in Mahazat does not alone account for the Lappet-faced Vulture's distribution there, and that other factors seem to be involved. The increase in the use of *Acacia tortilis* trees for nesting found in this study is probably related to a combination of low levels of disturbance in the Reserve and the availability of trees for nesting purposes. Moreover, an aerial survey carried out in May 1990 estimated a recovery rate of 6.06% for *Acacia* and 0.03% for *Maerua*. In addition, the density of *Acacia* was higher than *Maerua*, with a mean of 553 *Acacia* trees/ha and 0.16 *Maerua* trees/ha (Gillet and Launay 1990). The aerial survey also showed that there was increase in density of *Acacia* from north to south of the Reserve, with highest density (2,905 *Acacia*/ha) located in the *Acacia* core area (Fig. 3), and minimum density (21 *Acacia*/ha) in the north-west (Gillet and Launay 1990). Furthermore, during a 2008 ground census Cunningham (2009) estimated the density of *Acacia* as 120/ha as against *Maerua* <1/ha. Regardless of difference in the densities estimated by these two studies, *Acacia* is the more dominant tree in the Reserve.

The reasons for concentration of nests in the two core areas in the early period of the study were difficult to determine, as monitoring of nests started only after the establishment of the Reserve. However, the high densities and height of trees in these areas, compared to the rest of the Reserve (owing to the terrain and the small *wadis* in these areas), probably explain this clustering of nests, along with the low level of disturbance to breeding vultures in the Reserve (Gillet and Launay 1990; Newton and Newton 1996; Shobrak 2005; Cunningham 2009). In addition, wood-cutting outside the Reserve has an impact on the density and height of trees, compared to inside the Reserve.

The security of the area together with an abundant food supply, in and around Mahazat, are probably the main factors responsible for the increase in vultures nesting in the Reserve (Shobrak 2003). Arabian gazelles and Oryx, suffering mortality during droughts (Seddon *et al.* 2003; Ostrowski and Williams 2006; Islam *et al.* 2007), were the main food. Even outside the Reserve, Shobrak (2000) showed that only 35% of the carcasses were utilized by other avian species and mammals, which means that there is an abundant food supply for the vultures.

In general, disturbance of nesting sites is probably one of the major reasons for the decline of raptors (Newton 1979; Mendelssohn and Leshem 1983; Mundy *et al.* 1992; Shobrak 2003). Outside the Reserve there are enough trees to support breeding of Lappet-faced Vultures, but the large number of Bedouin camps, which use these trees and surrounding areas, must have increased the levels of disturbance on breeding birds. Unfortunately, the vulture's large size causes local people to think that this bird will attack their livestock. There is clearly a need for an awareness campaign to explain that the species poses no threat to livestock and needs conservation.

Suitable nesting trees outside the Reserve are surrounded by fences for corralling domestic herds overnight (Shobrak 2003, 2004). In all non-active nests located outside the Reserve large stones were found inside the nests and between the branches, suggesting human persecution or at least disturbance of nesting vultures. Jennings and Fryer (1984) reported that local shepherds try to destroy eggs by throwing stones into the nests. In Israel, Lappet-faced Vultures also suffered from disturbance at nest sites because of the new settlements and military activity near the birds' nesting grounds (Bruun 1981; Mendelssohn and Leshem 1983).

Mundy *et al.* (1992) suggested that in preferred habitat the species nests in a random rather than regular fashion, and that a pair of vultures may make a new nest each year, 70 m to nearly 4 km from the previous site. In Zimbabwe, the average inter-nest distance of 64 nesting sites among 25 pairs was 1.2 km in one year. By contrast, the inter-nest distance of the same pairs in the following year was double, at 2.9 km (Mundy *et al.* 1992). In one year in the Serengeti, 11 of 25 pairs built a new nest, whereas in Zululand (South Africa) 11 nests and pairs have remained in the same tree over a 13-year period (Mundy *et al.* 1992). What drives these differing behaviours is not known, but similar results to the Serengeti study were recorded in Mahazat, with variations in the distribution of nests and a mean distance of 3.11 ±1.61 km between nests.

All nests in the Reserve were located in open areas with large trees suitable for breeding. However, these trees are mostly found in the main *wadis* and depressions where water remains for longer periods following rainfall. These conditions also encourage a good vegetation cover, and this attracts the local shepherds and their livestock. Lappet-faced Vultures were therefore attracted to nest in the areas which had the highest levels of disturbance (Shobrak 2003). All shepherds interviewed said that they used the largest trees in the area for shade for themselves and their livestock, and were heavily dependent on this shelter. The largest trees that are most suitable for nesting by Lappet-faced Vultures are therefore likely to be sites of intense human disturbance, which will discourage birds from using them. Moreover, most shepherds questioned considered that vultures might attack their livestock, and they did not encourage nests near camps (Shobrak 1996). Cunningham and Cunningham (1999) found similar perceptions by farmers towards vultures in Namibia.

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NEW DESCRIPTION

SPECIES DIVERSITY OF GENUS *MICROLEJEUNEA* STEPH. (LEJEUNEACEAE, HEPATICAE) IN NILGIRI HILLS, WESTERN GHATS, TAMIL NADU, INDIA

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A survey of *Microlejeunea* Steph. (Lejeuneaceae) from the Nilgiri hills, Western Ghats, Tamil Nadu, India, is presented with *M. udari* described as a new species. *Microlejeunea punctiformis* and *M. ulicina* reported for the area are also discussed.

Key words: Bryophyta, Hepaticae, India, Lejeuneaceae, *Microlejeunea*, Tamil Nadu, Taxonomy

INTRODUCTION

The genus *Microlejeunea* Steph., as the name implies, includes highly reduced species among the members of the Lejeuneaceae and is distributed in tropical as well as temperate parts of the world. The genus is extremely delicate (often polymorphic) and needs specialized microclimate. About 80 species are described across the world, most of them described by Stephani (1915). The taxonomic position of the genus always remains difficult. Mizutani (1961) was followed by Schuster (1980) who treated *Microlejeunea* as a subgenus of *Lejeunea* Lib., while Vanden Berghen (1948) was followed by Gradstein (1979) who separated *Microlejeunea* from *Lejeunea* on the basis of relatively small size and appearance of plant along with large size of leaf-lobule, and treated *Microlejeunea* as genus. *Microlejeunea* is characterized by small-sized plant, stem never exceeds 7 cortical and 3 medullary cells, while the leaf lobule covering 3/4 leaf lobe area, leaf and leaf-lobule always parallel with stem, never spreading, often with 1-2 ocelli, cells thick-walled and without trigones.

Earlier, 8 species of *Microlejeunea* were reported from India, including *M. aligera* (Mitt.) Steph. (now *Lejeunea aligera* Mitt.), *M. gracillima* Mitt. (name unresolved: http://www.theplantlist.org/tpl/record/tro-35209681) (now *M. punctiformis* (Taylor) Spruce), *M. longirostris* Steph. (now *L. longirostris* (Steph.) E.W. Jones), *M. inflatiloba* Steph., *M. microstipula* Steph., *M. minutistipula* Steph., *M. ulicina* (Taylor) A. Evans and *M. punctiformis* (Taylor) Spruce (Stephani 1915; Agarwal 1986). The Nilgiri hills, in the present state of our knowledge, host three species, *M. punctiformis, M. udari* and *M. ulicina*, the second described here as a new species from Pykara (Nilgiri hills), and subsequently collected from Porthimund Reserve Forests of the Western Ghats – a hotspot of global biodiversity. The species is easily separable from other known species.

Key to the species of *Microlejeunea* in the Nilgiri Hills

1. Plants 0.1-0.19 mm wide, underleaves as wide as the stem, female bract with entire margin 2
— Plants 0.19-0.3 mm wide, underleaves twice as wide as the stem, female bract with dentate margin .. *M. udari* sp. nov.
2. Leaf-lobe with a sub-acute apex .... *M. punctiformis*
— Leaf-lobe with a rounded apex .... *M. ulicina*

1. *Microlejeunea punctiformis* (Taylor) Spruce (Fig. 1)

In: Steph., Sp. Hep. 5: 832. 1915—*Lejeunea punctiformis* Taylor, *In*: Gottsche., Lindenb. *et* Nees, Syn. Hepat. 767. 1847.

Plants prostrate (isolated), yellowish-green, up to 7-10 mm long, 0.42-0.5 mm wide, shoot zigzag in appearance. Growth habit deliquescent, ramification pattern irregularly pinnate. Branching '*Lejeunea*-type'. Stem 32-38 µm in diameter, 3 cells across, differentiated, with 7 large cortical cells and 3 small medullary cells. Leaves contiguous, obliquely inserted, erect spreading, parallel to stem. Leaf-lobes ovate-oblong, 0.18-0.26 mm long, 0.9-0.15 mm wide, apex subacute, margin entire. Leaf cells thin-walled, apical and median cells 5-13 x 6-10 µm, basal cells 8-13 x 6-12 µm, ocelli 1 or 2 at basal cells. Leaf lobules large, 3/4 of the lobe length, first tooth only single celled, slightly acute. Underleaves small, distantly as wide as stem, bifid, 1/2 of their length, sinus deep, lobe triangular, subacute. Plants sterile.

Type Locality: southern India (*sic* Stephani, 1915).

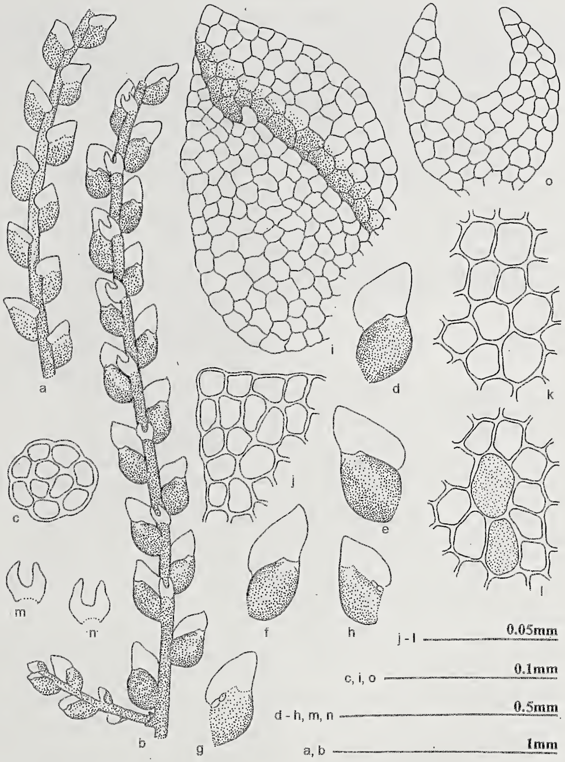

Fig. 1: *Microlejeunea punctiformis* (Taylor) Spruce (a-o from *Srivastava and party* 12636, LWU)
a: Plant, dorsal view, b: Plant, ventral view, c: Cross section of stem, d-h: Leaves, i: Leaf, magnified, j: Apical cells of leaf-lobe, k: Median cells of leaf-lobe, l: Basal cells of leaf lobe showing ocelli, m and n: Underleaves, o: Underleaves, magnified

Range: ASIA: India, Japan (Furuki and Mizutani 1994; Mizutani 1971).

Distribution: INDIA: Eastern Himalaya: Arunachal Pradesh; Sikkim – Nathu La Road; Manipur – Ukhrul; West Bengal – Darjeeling (Rimbic). southern India: Western Ghats: Karnataka – Mercara; Kerala – Ponmudi; Tamil Nadu – Nilgiri hills [Ootacamund (Emerald, Government Botanical Garden)].

Habitat: The species grows in thread-like forms (mainly diffuse patches) as epiphytic population on the bark of trees.

Representative Specimens Examined: JAPAN: Kyushu

– Miyazaki, Nakagol, 400 m, bark of *Cryptomeria japonica*, 1950, Coll.: S. Hattori, 141 (Hepaticae Japonicae). INDIA: Western Ghats: Tamil Nadu: Nilgiri hills, Ootacamund, Emerald, 1,800-1,900 m, 1983, Coll.: R. Udar and party 7079 (LWU). Ootacamund, Government Botanical Garden, 2,250 m, 2000, Coll.: S.C. Srivastava and party, 12636 (LWU).

Microlejeunea punctiformis is characterized by sparsely branched plants, leaves ovate-oblong with subacute apex, leaf-lobule covering 2/3 of the lobe. The species is similar to *M. ulicina* in overall characters, except in leaf morphology. The leaf apex is subacute in the former while rounded in the latter. Mizutani (1971) stated that both the taxa may be conspecific, but after the study of several collections from different Indian localities we here conclude that both species are easily separable.

2. ***Microlejeunea udari*** sp. nov. (Fig. 2)

Plantae dioeciae, caulibus prostratis ad 7 mm longis irregulariter pinnatis. Folia contigua ad subimbricata, loborum margo posticus arcuatus leniter crenulatus, cellulae basales 25-32 μm longae 16-20 μm latae, apicales 13-18 μm longae 16-21 μm latae ocelli cellulis vicinis parum maiores, lobuli 3/4-plo lobi longitudine inflate ovati. Gynoecia intercalaria. Folia floralia orbicularia, lobis obovatis margine dentate saepe crenulato dentibus 2 vel 3 cellulis longis apice acuto, lobulis oblongis ad lingulatis. Perianthium obovatum.

Typus: INDIA: Tamil Nadu: Nilgiri hills – Ootacamund, Pykara, 2,100 m, 29.iii.2001; Coll.: P.K. Verma and A. Alam, 13636 (Holotype LWU).

Paratypes: INDIA: Western Ghats, Tamil Nadu, Porthimund Reserve Forest, 2,200 m, on angiosperms, Coll.: P.K. Verma, 18035/2005 (Paratype LWU).

Plants prostrate pale green to dark green, up to 7 mm long, 0.49 mm wide. Growth habit deliquescent, ramification pattern irregularly pinnate. Branching '*Lejeunea*-type'. Stem 4 cells across the diameter with 7 large cortical cells and 3 small medullary cells. Leaves remote, contiguous to sub-imbricate, obliquely inserted, sub-erect spreading. Leaf-lobes ovate, flat, 0.29-0.36 mm long, 0.20-0.32 mm wide, apex rounded, antical and postical margin arched, margin weakly crenulate. Cells thick-walled, apical cells 13-18 x 16-21 μm, median cells polygonal 16-24 x 13-18 μm, basal cells 25-32 x 16-20 μm, ocelli slightly large, 30-34 x 22-26 μm, larger than neighbouring cells. Leaf-lobules large, 3/4 of the lobe length, keel strongly convex, inflated, ovate, 0.15-0.18 mm long, 0.12-0.15 mm wide, apical tooth 1-celled, not curved, margin crenulate. Underleaves twice as wide as stem, distant, sub-transversely inserted, orbicular, 0.06-0.09 x 0.06-0.09 mm, bilobed, 1/2 of the lobe length, lobe triangular and acute. Dioecious. Androecia not seen. Gynoecia intercalary in position, gynoecial innovation single, inflorescence pattern monochasial. Female bracts in single pair. Bract-lobes obovate, 0.6-0.62 mm long, 0.42-0.48 mm wide, long keel with an irregular sinuous wing, margin dentate, often crenulate with 2-3 cells long dentitions. Bract-lobules oblong to lingulate, 0.5-0.54 mm long, 0.2-0.26 mm wide, triangular, acute at apex. Bracteoles oblong, 0.3-0.32 mm long, 0.12-0.14 mm wide, shallowly bifid, lobes divergent, margin irregularly crenate with 1-2 celled teeth. Perianth obovate, 0.5-0.54 mm long, 0.26-0.28 mm wide, 5-keeled. Sporophyte not seen.

Type Locality: INDIA: Western Ghats, Nilgiri hills.

Range: Endemic to India.

Distribution: INDIA: southern India: Tamil Nadu, Nilgiri hills [Ootacamund (Pykara), Porthimund Reserve Forest].

Habitat: Plants growing in thread-like forms (in loose patches) as epiphytic population on bark of angiosperms.

Characteristics of the New Species:

1. Plants pale green to dark green.
2. Leaves contiguous to subimbricate, margin crenulate.
3. Leaf lobule inflated, ovate, 2/3 of the lobe length.
4. Underleaves twice as wide as stem, bifid, 1/2 of the lobe length.
5. Dioecious.
6. Female bracteole connate on both sides of bracts, margin of bracts and bracteole irregularly and highly crenulate.

Microlejeunea udari sp. nov. is a distinctive species recorded from Pykara and Porthimund Reserve Forest of Nilgiri hills. The species is different from *M. ulicina* and *M. punctiformis* in the structure of female bracts. *M. udari* sp. nov. has irregularly dentate bract margin with 1- or 2-celled protruding teeth and underleaves twice wide as stem, while the other two species have entire margin of the bract and the underleaves are as wide as stem.

Etymology: The *Microlejeunea udari* is named as a token of respect for the teacher of the one of the authors (Surech C. Srivastava), Prof. Ram Udar, FNA and renowned bryologist of the country.

3. ***Microlejeunea ulicina*** (Taylor) A. Evans (Fig. 3)

Mem. Torrey Bot. Club. 8: 162, 165, 176. 1902.

Plants prostrate (isolated), pale yellowish to green, up to 10 mm long, 0.3 mm wide; shoot zigzag in appearance.

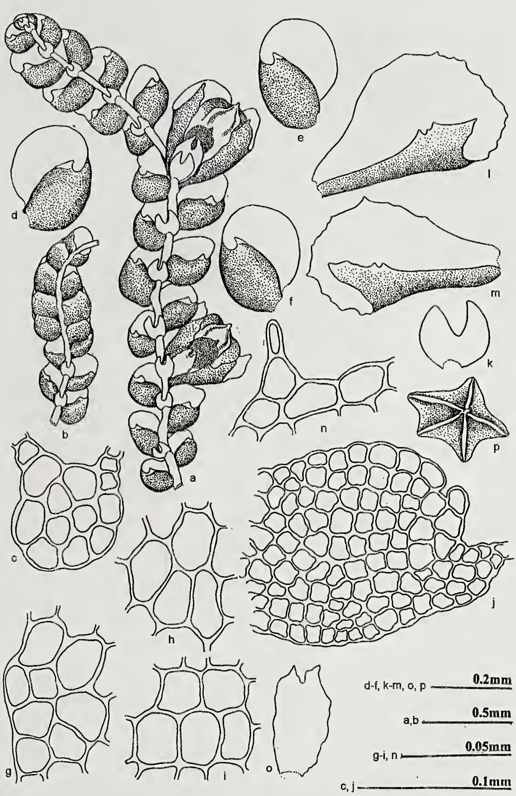

Fig. 2: *Microlejeunea udari* sp. nov.
a: Female plant, ventral view, b: Male branch, ventral view, c: Cross section of stem, d and f: Leaves, g: Apical cells of leaf-lobe, h: Median cells of leaf-lobe, i: Basal cells of leaf-lobe, j: Leaf-lobule, magnified, k: Underleaf, l and m: Female bracts, n: Marginal cells of female bract, o: Female bracteole, p: Cross section of perianth

Growth habit deliquescent, ramification pattern irregularly pinnate. Branching '*Lejeunea*-type'. Stem 29-34 µm in diameter, 3 cells across the diameter, with 7 relatively large cortical cells and 3 small medullary cells. Rhizoids arising from underleaf base. Leaves contiguous, obliquely inserted, sub-erect spreading. Leaf-lobes ovate, strongly convex, 0.13-0.19 mm long, 0.12-0.19 mm wide, apex rounded, margin entire. Cells sub-quadrate, thick-walled, apical cells 3-6 x 3-6 µm, median cells 5-9 x 5-8 µm, basal cells 7-12 x 6-8 µm, ocelli 1-2, similar to adjoining cells. Leaf-lobules large, 3/4

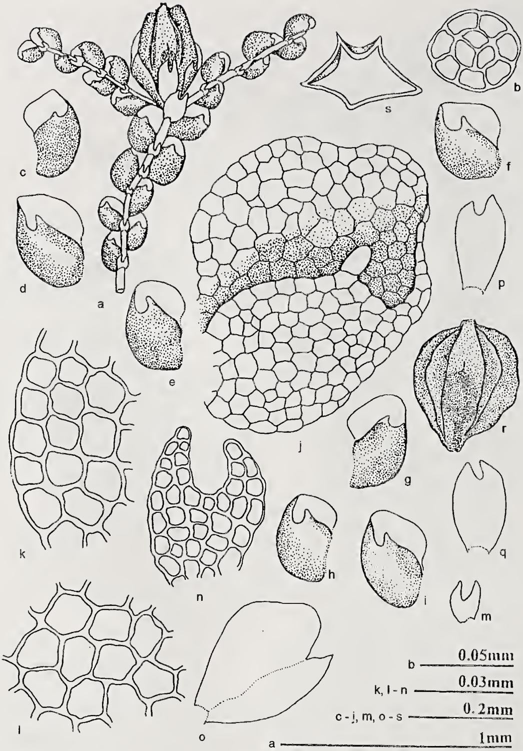

Fig. 3: *Microlejeunea ulicina* (Taylor) A. Evans (a-s from Srivastava and party 12510, LWU)
a: Female plant, ventral view, b: Cross section of stem, c-i: Leaves, j. Leaf, cellular, k: Apical-marginal cells of leaf-lobe, l: Median cells of leaf-lobe. m: Underleaf, n: Same, magnified, o: Female bract, p and q: Female bracteole, r: Perianth, s: Cross section of Perianth

of the lobe length, first tooth only single celled, obtuse. Underleaves as wide as stem, bifid, 1/2 of their length, 48-70 µm long, 42-53 µm wide, lobes narrow, 3 cells long, 2 cells wide. Dioecious. Androecia not seen. Gynoecia terminal on main shoot as well as on short lateral branches, gynoecial innovation 1 or 2, inflorescence diffuse. Female bracts much larger than leaves. Bract-lobes obovate-oblong, 0.33-0.37 mm long, 0.19-0.22 mm wide, apex rounded, margin entire, bract-lobule irregular in shape, oblong, apex rounded. Bracteoles free from bract, obovate to oblong, 0.27 mm long, 0.13 mm wide, bifid. Perianth inflated, obovoid, 0.45-0.78 mm long, 0.32-0.40 mm wide, smooth, 5-keeled. Sporophyte young.

Type Locality: Ireland: Kerry county – Kenmore (Schuster, 1980)

Range: AFRICA: Ivory Coast; U.S.A.: Canada, SOUTH AMERICA: Brazil, Chile; ASIA: Japan; EUROPE: Azores, Britain, France, Italy, Luxembourg, Madeira, Canary Isle (Mizutani 1979; Zhu and So 2001).

Distribution in India: Eastern Himalaya: Meghalaya – Kanchipur, Vishnupur; Sikkim – Nathu La road. southern India: Western Ghats: Karnataka – Agumbe, Jog falls; Kerala – Lakkidi, Ponmudi, Silent Valley; Tamil Nadu - Nilgiri hills [Gudulur (Anumapuram, Cherambadi, Nellakotta, on way to Frog hill point to Wilson plantation, Naduvattam Reserve forest, on way to Yellamalai, Pandalur), Kotagiri (Elada, Kilkotagiri, on way to Kodnad, Nedgula, Quin Sholai, Shollarmattum, St. Catherine waterfall), Mukurthi National Park (Governorsholai, on way to Mukurthi lake, Parson's valley), Ootacamund (Athecal, Dodabetta, Government Botanical Garden, Kamraj Sagar Reserve Forest, Kendurai, Love Dale, Glenmorgan, Melkahatty, on way to Pykara water fall, Sholur, Theetkul), Upper Bhavani (Avalanche) (Agarwal 1986)].

Habitat: The species grows in thread-like form as epiphytic population on bark of trees.

Representative Specimens Examined: INDIA: Western Ghats, Tamil Nadu, Nilgiri hills, Ootacamund, Dodabetta, 2,660 m, 2000, Coll.: S.C. Srivastava and party, 12417, 12419, 12421, 12424, 12425, 12427 (LWU). Upper Bhawani, Avalanche, 2,250 m, 2000, Coll.: S.C. Srivastava and party, 12529, 12569, 12570, 12571, 12577, 12578 (LWU). Ootacamund, Government Botanical Garden, 2,250 m, 2000, Coll.: S.C. Srivastava and party, 12603, 12623 (LWU). Kotagiri, Kilkotagiri, 1,900 m, 2001, Coll.: P.K. Verma and A. Alam, 14335, 14337, 14339, 14344, 14347, 14349, 14366, 14372 (LWU). Ootacamund, Pykara waterfall, 2,100-2,200 m, 2001, Coll.: P.K. Verma and A. Alam, 14455, 14456, 14458, 14448, 14476, 14482, 14490 (LWU). Gudulur, Anumapuram, 2,100 m, 2001, Coll.: P.K. Verma and A. Alam, 14511, 14514, 14515, 14524, 14525 (LWU). Mukurthi National Park, on way to Mukurthi lake, 2,250 m, 2001, Coll.: P.K. Verma and A. Alam, 14541, 14553, 14554 (LWU). Ootacamund, Glenmorgan, 2,200 m, 2001, Coll.: P.K. Verma and A. Alam, 14678 (LWU). Gudulur, Nellakotta, 1,200-1,400 m, 2002, Coll.: P.K. Verma, A. Alam and N. Sahu, 14886, 14903, (LWU). Mukurthi National Park, Parson's valley, 2,250 m, 2002, Coll.: P.K. Verma, A. Alam and N. Sahu, 15257, 15309 (LWU). Goverener Sholai, 2,200 m, 2002, Coll.: P.K. Verma, A. Alam and N. Sahu, 15470, 15471, 15478 (LWU). Gudulur, Devala, 1,300 m, 2002, Coll.: P.K. Verma and A. Alam, 16022 (LWU).

This is one of the common species of *Microlejeunea* distributed widely not only in India but across the world (Schuster 1980). The species is characterized by up to 10 mm long and 0.3 mm wide plant, ovate leaves with rounded apex and 1-2 gynoecial innovations.

ACKNOWLEDGEMENTS

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REVIEWS

1. BIRDS OF THE INDIAN SUBCONTINENT by Richard Grimmett, Carol Inskipp and Tim Inskipp, 2011, Second Edition. Published by Christopher Helm, an imprint of Bloomsbury Publishing Plc., Oxford University Press, UK. Size: 21.5 cm x 14 cm, 528 pp. Paperback. Price: Rs. 875/-.

For almost 20 years, since its first appearance in 1983, the PICTORIAL GUIDE TO THE BIRDS OF INDIA AND PAKISTAN by Sálim Ali and S. Dillon Ripley remained the only field guide that covered almost all bird species of the Indian subcontinent. Despite its bulky and awkward size, and haphazardly numbered illustrations, it was a 'bestseller' of the BNHS and reigned unchallenged till 1998 when the authoritative BIRDS OF THE INDIAN SUBCONTINENT by Richard Grimmett, Carol Inskipp and Tim Inskipp was published. It was not a field guide, so, it did not make much difference to amateur birdwatchers. In 1999, the publication of a field guide, which they called POCKET GUIDE TO THE BIRDS OF THE INDIAN SUBCONTINENT revolutionized bird watching in India, despite muted protest by old timers who had lived for years on Ali's and Ripley's books.

The major drawback of the first edition of the POCKET GUIDE was that the authors had not only changed common names (some on trivial reasons), but also the classification. So, instead of having grebes and shearwaters in the first few pages, as in the 'standard' bird books, their book started with Nicobar Megapode and partridges/snowcocks as the first plate. Grimmett *et al.* had followed the taxonomy and sequence from the book DISTRIBUTION AND TAXONOMY OF BIRDS OF THE WORLD by C.G. Sibley and B.L. Monroe, Jr. (1990). Nomenclature was adopted from the book AN ANNOTATED CHECKLIST OF THE BIRDS OF THE ORIENTAL REGION by Tim Inskipp, Nigel Lindsey and William Duckworth. Therefore, Red Munia became Red Avadavat, Long-billed Vulture became Indian Vulture, and most interestingly woodpeckers, honeyguide and wryneck came after ducks! Sibley and Monroe's classification was based on DNA analysis, which proved that woodpeckers are close to ducks.

The animal classification follows a general pattern, with the most primitive species first (i.e. bottom of evolutionary tree) and the most advanced at the end (i.e. the top). Related species with common ancestry and shared characteristics are put near each other and illustrated for easy understanding of the evolutionary tree (dendrogram). How a honeyguide is more closely related to ducks than other birds was difficult to accept. But genetic studies sometimes give unexpected results. The case of close relationship of a hyrax and elephant is a well-known text book subject. Both are so different in shape, size and behaviour, but considered as evolutionary 'siblings'.

Besides the arrangement and sequencing of species/groups that had confused many, another drawback of the earlier books of Grimmett *et al.* was distribution map of species. The maps were based on published and museum records, and not indicative maps based on continuity and availability of suitable habitat. In a vast Subcontinent like ours, with very limited bird recorders, most distribution maps are location points of ornithologists/birdwatchers than the actual distribution of a particular species. Absence of a recorder does not necessarily mean absence of a species, particularly if a suitable habitat is still present. This is especially true for migratory waterbirds, which can be found in any suitable wetland (admittedly some are found only in north India, for example Greylag Goose, while others in the whole country). In such cases, it is reasonable to give general indicative distribution maps.

In 2005, Pamela C. Rasmussen of Smithsonian Institution, Washington, DC, and a student of late Dr. S. Dillon Ripley published BIRDS OF SOUTH ASIA: THE RIPLEY GUIDE in two volumes. Volume I being a Field Guide and volume II covers Attributes and Status. This brought back the old classification to which many of us were used to. She also revived many subspecies/races into full species, and identified many cryptic species, based on morphology, distribution and songs. The criticism was that most of her 'new' splits (species) had not been described in detail in peer-reviewed journals so how could one accept the taxonomic change. The criticism is valid up to a certain extent, but we must appreciate that her suggestions were a challenge to all to prove or disprove her. Many papers published in SYSTEMATIC NOTES ON ASIAN BIRDS have proved that Pamela is correct.

Leaving aside the taxonomic debate, I will come back to the book under review. The second edition is a vast improvement with 226 colour plates, 73 more than in the first edition. In the first edition, some plates were irritatingly crowded with illustrations. For example, plate 71 of the POCKET GUIDE had 33 illustrations describing sitting and flight postures of five species of eagles and hawk-eagles, while in the new book the same species are described in two plates: three species of eagles are shown in 17 illustrations on Plate 45 (p. 128), and four species of hawk-eagles are shown in 17 illustrations on Plate 46 (p. 130). Based on taxonomic splits given in Pamela's book, two subspecies of Changeable Hawk-eagle have been described as full species: nominate

Changeable Hawk-eagle *Nisaetus limnaeetus* and Crested Hawk-eagle *Nisaetus cirrhatus*. Please note that the earlier generic name of hawk-eagles was *Spizaetus*. The other species illustrated on Plate 46 is that of Mountain Hawk-eagle, now in two forms: the nominate *Nisaetus nipalensis* of northern India, and *Nisaetus kelaarti* or Legge's Hawk-eagle of southern Western Ghats, which is a smaller bird. Other plates in the new edition are also less cluttered.

Almost all the plates have been re-composed, so now there are not more than 5-6 species per plate (including various postures, age and sex-related differences if any). As the authors write in the Introduction "many species and even a few families or groups have been repainted for this edition. Species texts have been significantly increased for almost all species, and the maps have been completely revised."

I must admit that although the maps have been considerably improved in the second edition, there are still many twists and turns, and enigmatic gaps in the polygons to make one comfortable. With extremely limited data of such a large number of birds in such a large and diverse country, producing good distribution maps of Indian birds is a real challenge. Additionally, we have destruction of forests and grasslands (destroying habitat of some species, while increasing habitats of others), destruction of natural wetlands and creation of artificial waterbodies, due to dams, reservoirs and canals, unpredictable weather and climate change – all of which are changing the distribution pattern of many peripatetic species. New information is not reflected on maps based on old museum records and published papers. Increasing popularity of bird watching in India and use of internet, facebook and twitter to report sightings has increased the scope of recording. A good photograph has now replaced specimen collection. What we urgently need is to publish distribution atlas of the birds of India. Till this is done, most of our field guides will have confusing distribution maps.

A total of 1,313 species have been described in the Indian subcontinent. Adding the number of potential splits as full species, this book describes 1,375 species – formidable task indeed. Printing and other production quality is top class. Earlier POCKET GUIDE had numbers below the illustrations while in this book, species names have been given, which further enhance the quality and usefulness of the book. I wish Peterson's patented arrow marks can be 'unpatented' so we all can use them in illustrated guides as a quick pointer to the characteristic features to look for in the field before a confusing green-pigeon or a *Phylloscopus* warbler flies away. In the bird rich forests of India, we all have cursed ourselves for missing the clinching characteristic feature – for instance noting everything except one feature that separates the Chestnut-crowned Bush-warbler *Cettia major* from the Aberrant Bush-warbler *Cettia flavalivacea*.

For 14 long years, the POCKET GUIDE (1999) was my field companion (along with Pamela's book from 2005) even when it was tattered and the book was held in place with a rubber band! Getting hold of this marvelous book is an un-describable pleasure, at home and in the field. At least for some years, I will not have to use a rubber band to keep the pages in place. I am sure before my second edition reaches that stage the third edition, with improved maps, will be in the market.

■ ASAD R. RAHMANI

2. TOWARDS CONSERVATION AND MANAGEMENT OF MANGROVE ECOSYSTEMS IN INDIA, 2011. Edited by J.R. Bhatt, D.J. Macintosh, T.S. Nayar, C.N. Pandey, B.P. Nilaratna. Mangroves for the Future (MFF) India & IUCN, India. Size: 25.5 cm x 17 cm, 280 pp. Hardbound. Price not mentioned.

Viewed in the not-so-distant past as hostile swamps, mangroves are recently looked upon by most people as wetlands worth conserving, being both a valuable ecological and economic resource. Nevertheless, despite this change in perception mangrove destruction continues unabated even today at alarming rate, the major threats being urban development, aquaculture and over-exploitation of fishery resources.

A number of books and reviews on mangroves are available. In fact, even a superficial survey of the current scientific literature indicates that research on systematics and ecology of mangrove ecosystems is steaming ahead at a rapid pace. Most of this literature deals with various aspects of biology, structure and functions of mangrove forests covering systematics, floristics, community structure, species diversity, species composition across salinity and soil types. While such a flow of information is extremely important to understand mangrove forests, a timely account on the information gaps, reviews on site-specific conservation activities and actual implementation of various research outputs in mangrove conservation is a need.

With this background, a two-day workshop on 'Conservation and Management of Mangrove Ecosystems in India – Stakeholder Consultation for Assessment of Training and Capacity Building Needs and Design of National Strategy and Action Plan' was held in February 2008 at GEER Foundation, Gandhinagar, Gujarat. The delegation included a wide range of audiences from the government to NGOs, stakeholders to fieldworkers representing countries, such as India and Sri Lanka. This book is the proceedings of this workshop with papers through twenty-two chapters, a picture stitched out of various case studies depicting the current state of mangroves in India.

The first chapter is a comprehensive account on the 'biodiversity of mangrove ecosystems in India' which outlines the current status of our knowledge and highlights gaps that need to be addressed for better conservation and management. The succeeding chapters deal with topics as diverse as reviews on overall mangrove species diversity in India, site-specific accounts of species diversity, flora–fauna interaction studies, coastal management in India, as well as specific case studies, including experiments and success stories, use of technologies in management (such as information technology, remote sensing, etc.). Gujarat, Andhra Pradesh, West Bengal (Sundarbans), Andaman and Nicobar, Karnataka and Kerala are the well-represented states among these chapters with various aspects of conservation. Absence of representation of Maharashtra in spite of its vast mangrove cover is unfortunate.

The book concludes with a page summary record of the workshop proceedings and recommendations. These recommendations emphasize mainly on capacity building among various target groups, including local communities, forest officials, researchers with respect to identification of health and habitat quality indicators, bio-prospecting mangrove resources, etc. The inter-institutional collaborations, development of databases, actual economic evaluation are some of the important key factors identified for strategic management of these ecosystems. Presentations of these chapters under various sections, such as diversity, case studies, management, etc. could have aided to make the story of conservation of mangroves in India more apprehensible.

The book has an attractive layout with around 156 spectacular coloured photographs, that liven the articles and makes reading pleasant. Certainly, it is not just 'yet another book on mangrove', unquestionably valuable for anyone who is concerned with mangroves, may it be a decision maker or an alert citizen.

■ SWAPNA PRABHU

3. SYSTEMATIC NOTES ON ASIAN BIRDS 2010. Edited by David R. Wells, BOC Occasional Publications No 5. Published by the British Ornithologists' Club in association with the Trust for Oriental Ornithology, Eastbourne, UK. Size: 24.5 cm x 17 cm, 148 pp. Paperback. Price not mentioned.

In 2000, the Nationaal Natuurhistorisch Museum (Naturalis), Leiden, and the Trust for Oriental Ornithology (TOO) started a series known as *Systematic Notes on Asian Birds* (SNAB). Five issues appeared annually as a part of the journal *Zoologische Verhandelingen* and, after the merger of Leiden titles, a sixth issue was published in 2006 as part 5 of volume 80 of *Zoologische Mededelingen*. As Helen Baker, Chairman of British Ornithologists' Club (BOC), has written in her preface of this volume, the Leiden Museum terminated the agreement to publish the series, therefore BOC came forward and made an agreement with TOO to continue this series. Although the present issue has been published after a gap of four years, the numerical continuity of the papers in the series is maintained, and David Wells continues to be the editor.

The present volume has research papers on some of the most taxonomically difficult and challenging taxa of Asian birds, such as the babbler subfamily Pellorneinae of which there are five species under genus *Pellorneum* in South Asia. There are nine papers on the taxonomy of Asian birds and one Letter to the Editor. Admittedly, these papers, like earlier papers in this series, are quite esoteric and technical and may not be totally understood by a lay birdwatcher, but they are quite important for writers of field guides, and most importantly, extremely important for revision of the HANDBOOK OF THE BIRDS OF INDIA AND PAKISTAN by Sálim Ali and S. Dillon Ripley, which is long overdue.

As Editor David Wells has written in his Foreword, mainly six broad categories of papers were published in this series till now: 1) Preliminary reviews, 2) Types compilations, 3) Taxonomic revisions and realignments, 4) Nomenclatural revisions, 5) Bibliographic research, and 6) History of collectors and collections. The SNAB 2010 volume under review features five of these categories. It may not be possible to give details of each category here so readers are requested to read SNAB 2010.

Bird taxonomy is under great flux, particularly after the advent of molecular taxonomy. For example, in paper no. 68 of this series, Cibois *et al.* (2010) have shown that genus *Graminicola*, previously treated as Old World warblers, belongs to family Timaliidae (babblers). In another paper on leaf-warblers, genera *Phylloscopus* and *Seicercus*, Martens (2010) has reconfirmed that *Seicercus burkii* complex now comprises of eight species, mainly based on molecular genetics and vocalization. Earlier, papers (e.g. Martens *et al.* 1999, Alstrom and Olsson 1999, 2000) had proved that *S. burkii*, considered as one species, with many subspecies till then, is a highly complex group of golden-spectacled warblers and could comprise of 8-10 species. Two new species to science, hidden in this complex were described: *Seicercus soror* Alstrom & Olsson, 1999 of Sichuan, China, and *S. omeiensis* Martens, Eck, Packert & Sun, 1999 of Omei, Shan, Sichuan, China. Similarly, the genus *Phylloscopus* is highly complex taxonomically and may still reveal many cryptic species. For example, *Phylloscopus calciatilis* from Vietnam was described as a new species as recently as 2009 (see Alstrom *et al.* 2009). 'Discovery' of this new species was mainly based on vocalization, DNA sequencing, and allopatry -- the latter not always necessary in every case as many taxa occur together.

Another interesting point that has come to the attention of bird taxonomists, and which need further refinement through good field data, is vertical allopatry, i.e., different taxa occurring at different heights (at least during the breeding season), with sharp lines of contact along the gradient. This altitudinal stacking was noticed in the Himalaya and China in *Seicercus* and *Phylloscopus* complex. For instance, in the Himalaya, 8-10 species of *Phylloscopus* occur sympatrically, but not necessarily syntropically.

In another paper in this volume, Mlíkovský (2010a) has reviewed grebes of family Podicipedidae. He recognized six grebe species of *Tachybaptus* and *Podiceps* occurring in the region covered by SNAB. The main morphological differences are in body size, and size and shape of the bill. The Asian Little Grebe *Tachybaptus* (earlier placed in *Podiceps*) *ruficollis* differ from European and African birds in having yellow, not red eyes. The other differences mentioned in this paper are the western populations (breeding from Iraq to India) that are short-billed and have much white on their secondaries, whereas eastern populations (eastern China to Japan and mainland SE Asia) that have longer bills and much less white on their secondaries. Jiri Mlíkovský has provisionally recognized four subspecies of *Tachybaptus ruficollis.*

Four species of *Podiceps* are found in SNAB regions, with three definitely occurring in India: Red-necked *Podiceps grisegena*, Great Crested *P. cristatus* and Black-necked *P. nigricollis* grebes. Horned Grebe *P. auritus* is vagrant in India, with one confirmed photographic record on the Kosi river near Ramnagar in Uttarakhand (Drijvers 1994).

In another paper in this volume, Mlíkovský (2010b) has described the type of Podicipedidae of SNAB region. Such details may not appeal to a regular birdwatcher, but are important to unravel taxonomic and nomenclature issues.

SYSTEMATIC NOTES ON ASIAN BIRDS (SNAB) is a highly technical series that should be present in any good library dealing with natural history and ornithology.

■ ASAD R. RAHMANI

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4. CONSERVATION AT THE CROSSROADS: SCIENCE, SOCIETY, AND FUTURE OF INDIA'S WILDLIFE by Ghazala Shahabuddin, 2010. Permanent Black and the New India Foundation. Ranikhet. Size: 21.5 cm x 13.2 cm, 244 pp., Hardbound. Price: 595/-.

Permanent Black, a publishing company, is known to publish thought-provoking books on conservation issues, and this book is one of the finest examples. As the sub-title indicates it is about conservation science, society, including the people who live and depend on natural resources for their livelihood and the future of India's diminishing wildlife and how to reverse this trend. The author is a well-read and well-travelled conservation biologist, with deep interest in civil society issues. Her work in Sariska Tiger Reserve, Rajasthan, is greatly appreciated by the local communities and conservationists. As she says in the beginning "This book is an attempt to try and understand the shortcomings of the varied strategies that have been adopted for biodiversity conservation by India since Independence, both in terms of policy as well as implementation." She has deliberately used the term 'biodiversity' rather than the more popular term 'wildlife' as for most people, wildlife means large mammals in thick forests, while biodiversity includes all living creatures.

She laments, "The chasm between biologists and social scientists seems insurmountable" (p. xix), but through this book she has tried to "carve out a middle ground that encompasses equally the views of social scientists and biologists." She discusses participatory conservation strategies that have been adopted by the government and communities.

The first chapter 'The Anatomy of a Failing Paradigm' discusses in length the crises that afflicted Sariska Tiger Reserve after disappearance of the tiger – a much discussed topic in newspapers. Interestingly, in the 900 sq. km Sariska, only 70-80 sq. km is viable tiger habitat (p. 6). She has a series of research projects in Sariska, since 2003. She describes Sariska in about 20 pages.

There are some mistakes, which could have been easily avoided with better editing. The maps are of low quality. For example, the Sariska map on page 3, the names of places cannot be read unless you use a magnifying glass. Terms like 'illegal poaching' (p. 5) could have been corrected. Poaching is an illegal activity: there is no legal poaching.

'Reclaiming the Wilderness' in chapter 1 is an interesting sub-heading and should be read by all biologists. She ends the chapter by simple recommendations in two pages. She suggests understanding the ecological history of the area for designing administrative responses to conservation crises. From the start, the relocation of villages was made a priority in PA management, as though local forest use and locally abetted tiger poaching were the sole obstacles to effective conservation.

In Chapter 2, titled 'Displacement Nemesis: Creating people-free spaces', she describes the difficulties of Gond tribals who have been moved from the village of Botezari in the heart of Tadoba to New Botezari or Bhagwanpur. When living in forests, the average annual monetary income of a forest household from commercially sold forest and agricultural products, and daily-wages labour amounted to Rs. 8,870/-. In addition, they consumed forest and agricultural products (in the form of fodder, food, paddy), whose monetary value was estimated at Rs. 314,241/- annually per household (pp. 61-62). Obviously, the government rehabilitation agencies had not taken these benefits from the forest or their commercial value into account while planning the rehabilitation package. The total amount allocated per family for rehabilitation was only Rs. 100,000/-, including land filling, house construction, and communal infrastructure development.

Compared to the displacement caused by development projects, PA-related displacements have been rather small. Even if we take Kalpavriksh data of 20,000 families (*c.* 120,000 people) displaced from 23 PAs, it is still rather small when compared to displacement due to large dams, canals, roads, mines, etc., which have resulted in displacement of millions of people. However, as she has rightly pointed out, by quoting several studies, conservation-related displacement of people disproportionately affects marginalized tribal groups who are in no position to adjust to their new environment which cuts off their lifestyle. These tribals generally do not possess the education, language, skills, and exposure to markets that are required by them to adjust to their new environment. Therefore, a "great deal of sensitivity to ethnicity and history, and careful attention to the development of new livelihood skills, as well as to the deployment of existing traditional knowledge, are imperative if relocation are to have even a remote chance of success" (p. 69). As was shown in relocation of 419 households from the Bhadra TR in 2002, it can be done successfully, if done by committed forest officers and involvement of local NGOs (p. 76). Successful rehabilitation can be achieved by site-specific modification to the rehabilitation packages and greater involvement of people who have to be relocated. She has rightly concluded that displacement option should not be foreclosed only because it has been difficult or badly managed, this far.

There are very profound statements in this book that force one to think about the whole conservation paradigm. For example, savour this statement "The inequities in protected area management seem to closely mirror not only the deep inequities in Indian society, but also, ironically, the pathetically low values that urban Indians typically associate with common spaces and the common good."

One of the most interesting chapters, relevant to Indian researchers, is appropriately titled 'The Endangered Tribe of the Wildlife Biologist' (Chapter 3). She has given some examples where foreigners, particularly the USA/Smithsonian Institution were not allowed to work in India, but she is wrong when stating that such collaboration have not taken place earlier. The U.S. Fish and Wildlife Service has funded many projects of the BNHS, WII, and other institutions.

The book has readable language and flow of thoughts, despite quoting numerous references and short-notes. I strongly recommend this book to students, conservation biologists, protected area managers, decision makers sitting in Delhi and state capitals, and also social scientists working with communities.

■ ASAD R. RAHMANI

MISCELLANEOUS NOTES

1. SIGHTING OF DHOLE OR INDIAN WILD DOG *CUON ALPINUS* AT FAKIM, KIPHIRE DISTRICT, NAGALAND, INDIA

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While driving from Fakim village (25° 48' N; 94° 56' E) to Pungro (25° 51' N; 94° 54' E) Kiphire district, Nagaland, on May 02, 2011, we saw a pack of six dholes *Cuon alpinus* crossing the track around 15:45 hrs. Their progress was disturbed / intervened by the appearance of a local villager at the other end of the road. Cornered between our slow moving vehicle and the man on foot, who was pelting stones at them, they reacted immediately. The two adults and two pups, which were in front, bolted and managed to cross the road to vanish into the dense undergrowth, while two pups hesitated, and instead of following their parents, retreated downhill. They were thus separated from the main pack and were attacked by the villager. Fortunately, the pups were not hit by the stones thrown by the villager and they managed to escape.

In India, dhole is still found throughout much of its landmass south of River Ganges, especially in the Central Indian Highlands and the Western and Eastern Ghats of the southern states. They are also found through the states of Arunachal Pradesh, Assam, Meghalaya and West Bengal. In the Himalayas and north-west India, their status is more precarious with a more fragmented distribution. They reportedly still exist in Ladakh. In Bhutan, there have been recent press reports that dholes have recovered from a government-initiated mass poisoning campaign in the 1970s. Two independent eyewitness reports identify dholes in six protected areas of Bhutan.

Dhole is listed as Endangered in the IUCN Red List (2011). The latest estimates are that of fewer than 2,500 mature individuals in the wild. Our knowledge of dhole population is limited to the estimates of their numbers within a few protected areas in southern and central India. Abundance is relatively lower in West Bengal, Assam and Arunachal Pradesh. In the rest of north-eastern India, dholes are completely extinct or close to extinction (Durbin *et al.* 2004). No remotely comparable information on their population density is available for any part of South-east Asia, and there is no empirical data available for this region (Sillero-Zubiri 2009).

The status of dholes in the wetter forests of north-east India and Bangladesh is unknown though the species is thought to be rare or extinct in most of the north-east Indian states (except for Meghalaya and Arunachal Pradesh) and the Chittagong hill tracts of Bangladesh (Venkataraman and Johnsingh 2004). Thus, their status remains uncertain for north-east India. We are not aware of any recent sightings of dhole from Nagaland, except sightings by Angulie Meyase who has frequently travelled in different parts of Nagaland with foreign tourists. He sighted dholes twice in the forest near Khonoma. Four dholes were seen by him in around 2009 and one in 2010 (Angulie Meyase pers. comm.).

Our observations merit comment as the status of the mammal remains very vague within north-east India.

According to Venkataraman and Johnsingh (2004), viable populations may exist in northern Myanmar, where despite sufficient vegetation cover prey densities tend to be low. Recently in Myanmar, dholes were recorded by camera traps at 11 of the 15 survey areas scattered across the country (Durbin *et al.* 2004). *C.a. adustus*, a subspecies found in Myanmar, may range into adjacent parts of north-eastern India (Venkataraman and Johnsingh 2004). It is possible that the pack we sighted belongs to the Myanmar race although the HANDBOOK OF THE MAMMALS OF THE WORLD recognizes only three races, *C. a. alpines* (Pallas, 1811) which occurs in central Russia and western China south through India to Bhutan and Bangladesh, *C.a. hesperius* (Afanas'ev and Zolotarev, 1935) which occurs in eastern Russia, China and South-East Asia, and *C.a. sumatrensis* (Hardwicke, 1821) which occurs in Sumatra and Java (Sillero-Zubiri 2009). Prater (1971) recognized only three races within the Indian limits – a trans-Himalayan, a Himalayan and peninsular form.

It is possible that free ranging packs from neighbouring Myanmar cross into India. However, keeping in mind the age (*c.* five months) of the pups it is likely that the pack we observed belonged to the Fakim area itself. The pup were old enough to be mobile as they accompanied the adults on the move. Dholes reach adult size by about 15 months

(Venkataraman 1998) although by about three months the pups accompany the adults during hunts (Johnsingh 1982). However, the pack may not be completely mobile until about eight months (Venkataraman 1998).

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2. NORTHERN TREESHREW *TUPAIA BELANGERI* IN SOUTHERN MIZORAM, INDIA

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North-east India comprising of the states of Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya and Tripura forms a part of a rich biogeographic unit and is among the biodiversity 'Hotspots' of the world (Choudhury 1999; Myers *et al.* 2000; Ved and Lalramnuna 2008). Formerly referred to as Lushai Hills of southern Assam (Choudhury 2008), Mizoram is situated between 21.58°-24.35° N and 91.15°-93.29° E covering an area of 21,081 sq. km (Anon. 2006). In broad terms, the forests of Mizoram are classified as 'Cachar Tropical Evergreen (IB/C3)' and 'Cachar Semi Evergreen (2B/C2)' (Champion and Seth 1964). Saiha in extreme south Mizoram shares a boundary with Lawngtlai to its north. Some of the best rainforests of north-east India are found in southern Mizoram, covering parts of the districts of Lawngtlai and Saiha (Choudhury 2006).

Treeshrews are entirely confined to South and South-east Asia, and the latter region has the largest number of species. Of the three species found in South Asia, two are confined to the mainland, namely the Madras Treeshrew *Ananthana ellioti* Waterhouse 1849 in peninsular India and the Northern Treeshrew *Tupaia belangeri* Wagner 1841 in north-east India (Oommen and Shanker 2008). I here report two recent records of the Northern Treeshrew from southern Mizoram.

I saw a Northern Treeshrew at Tuipang (22° 18' 55.728" N; 93° 1' 35.112" E), the headquarters of Tuipang block in Saiha district, on June 17, 2008. The shrew had been caught in a trap set in *jhum* (shifting cultivation) fields; was dead when I saw it. These non-baited traps, known as *mangkhawng*, are made using small logs and placed at the edge of crop fields (Ved and Lalramnuna 2008). This particular trap was *c.* 2.0-2.5 km from the town in a mosaic of old, new, and current shifting cultivation plots, with some village supply and safety reserves.

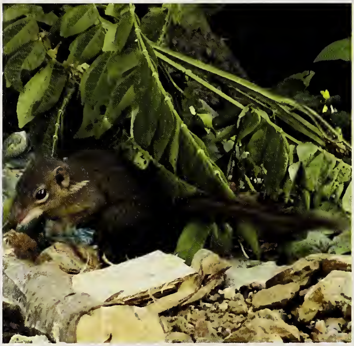

Fig. 1: Northern Treeshrew *Tupaia belangeri* at Saiha

I saw another treeshrew at our office in Saiha (22° 29' 15.4674" N; 92° 59' 8.16" E) on September 24, 2009, at 15:00 hrs. It had stopped raining and the sky had cleared. The treeshrew moved around young mango trees and shrubs about 3 m from the wall of our office in the middle of a primarily residential locality at the Saiha district headquarters. I saw it pushing plastic trash that lay around, presumably in search of food, and was also able to photograph it. I understand this is the only confirmed photographic record of the species in the wild from southern Mizoram.

Zonunmawia and Pradhan (2004) and Anon. (2006) did not list it. However, the treeshrew has been described in Reginald Lorrain's Seminal Mara (local language in Saiha) dictionary as '*Zyu-si* - shrew mouse' (Lorrain 1912), implying its presence in the landscape.

ACKNOWLEDGEMENTS

I am indebted to Kashmira Kakati, Aparajita Datta and Meera Oommen for identification with help of species and sharing of material. I thank S. Lalramnuna for the help at Tuipang and more importantly for being with me. Mr. Simon is acknowledged for the wonderful place that houses our home and office. I thank Samrakshan Trust, the organization I was then associated with.

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3. CONGREGATION PATTERN OF RED JUNGLEFOWL *GALLUS GALLUS* IN DUDHWA NATIONAL PARK, UTTAR PRADESH, INDIA

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Dudhwa National Park (DNP) is situated on the Indo-Nepal border (28° 18'-28° 42' N; 80° 28'-80° 27' E) in Nigahsan subdivision of Lakhimpur-Kheri district of Uttar Pradesh. The area falls under the Terai-Bhabar biogeographic subdivision of the Upper Gangetic Plain (7A), biogeographic classification of Rodgers and Panwar (1988). In 1977, the DNP was declared as a national park with a core zone of 490 sq. km and a buffer zone of 124 sq. km.

The Red Junglefowl (RJF) *Gallus gallus* is distributed along the foothills of Himalayas from Myanmar to north-western India, extending southward into the hills of peninsular India (Ali and Ripley 1987). It also occurs in tropical and subtropical habitats in southern China and South-east Asia, and has been introduced at several places (Sullivan 1991). To the north its distribution is limited by the Himalayan mountain range (Collias and Collias 1967). Red Junglefowl is common in DNP and occurs in different habitats, such as sal forest, mixed forest and teak forest (Javed and Rahmani 2000). Data on flocking composition of Red Junglefowl were collected from December 2005 to June 2007 in DNP, with an intensive study area of Dudhwa and Sonaripur ranges. Data was collected using vehicular transect, foot transect and in opportunistic records during the study period. A total of 635 individuals of the Red Junglefowl were seen during study period comprising 204 groups, out of which 428 individuals were seen in summer and 207 in winter. Chicks were also observed (n = 4) during May 2006 and June 2007 in sal forest only. Overall, the number of males were higher than the females (308 males to

300 females), in summer females were more in number than males (90 males:98 females) as compared to winter (220 males:200 females). The overall male to female ratio was 102:100 with 110:100 in winter and 91:100 in summer. Our results contradict the previous study (Javed and Rahmani 2000), where observed male to female ratio was 0.75:1.0 (n = 465) with 0.90:1.0 (n = 48) in winter and 0.72:1.0 (n = 417) in summer, but favours the congregation pattern observed by Collias and Collias (1967) in other moist deciduous forests in India. Maximum flock size of 11 birds was observed in sal forest both in winter and summer. However, Javed and Rahmani (2000) observed a bigger flock size of 20 individuals in winter in the DNP. Overall flock size was found to be 3.14 ± 0.14 S.E. Mean flock size was highest in winter (3.32 ± 0.18 S.E.) as compared to summer (2.84 ± 0.23 S.E.) and the difference was not significant. Among different habitats, mean flock size was highest at forest edges (3.24 ± 0.14 S.E., n = 29) followed by grassland (3.22 ± 0.53 S.E., n = 22), sal forest (3.21 ± 0.23 S.E., n = 84), mixed forest (3.08 ± 0.27 S.E., n = 46) and teak forest (2.76 ± 0.32 S.E., n = 21), and the difference was not significant. During the study on three occasions, Red Junglefowl were found copulating with the domesticated varieties found near human habitations in Dudhwa range. Thus, supporting the hypothesis put forth by Peterson and Brisbin (1998) that Red Junglefowl have hybridized with domesticated forms and that the hybrid genes have introgressed into wild populations, thereby contaminating the wild gene pool. Although, Kaul *et al.* (2004) observed 63 Red Junglefowl in different zoos of India, and concluded that all the birds have physical characteristics of a true junglefowl and considered them as true. Thus, we recommend a detailed genetic study of wild population not only in Dudhwa, but in the entire distribution range to check the contaminated level in true genetic traits of Red Junglefowl in the wild.

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4. AN UNUSUAL CASE OF MOULTING IN AN INDIAN FLAP-SHELL TURTLE *LISSEMYS PUNCTATA* (LACEPÉDE, 1788)

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On January 01, 2008, I procured a live specimen of an Indian Flap-shell Turtle *Lissemys punctata* from a fish market at Chetla road, Kolkata, West Bengal. As the species is protected under Schedule I of the Indian Wildlife (Protection) Act, 1972, the specimen was kept in a Snake Park for observation.

The turtle was kept in a tub (61cm in diameter and 15 cm in depth) with little water and *Ipomoea aquatica*. The turtle at times came out of the tub and moved freely in the room, preferably in darker places. On February 25, 2008, it disappeared and could not be found anywhere. On October 28, 2008 (almost 8 months later) the turtle reappeared and was found crawling on the floor. The turtle appeared to have survived without food and water during this period. Flap-shelled turtles are adapted to long periods of drought (Grazimek 2003) and are able to withstand prolonged starvation, and it was reported that a captive specimen lived for 2 years without food (Daniel 2002).

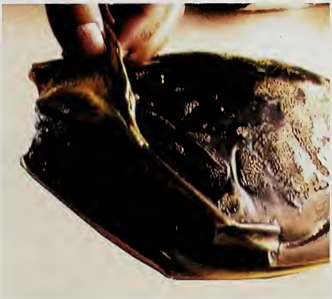

Fig. 1: Unusual moulting of the Turtle carapace

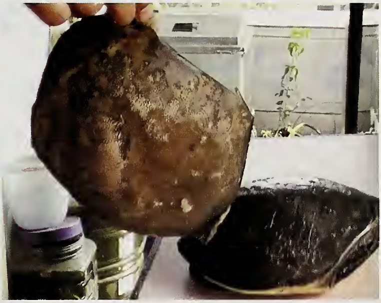

Fig. 2: The intact carapace shed by the turtle

After reappearing, the turtle looked dry and dirty. I washed it under running water and kept it in a bucket with water and *Ipomoea aquatica*, which was devoured instantly. A few white patches had appeared on the carapace of the turtle, and a few days later it casted its skin (Fig. 1). The casting process began with the soft parts (legs, neck folds) followed by the plastron and carapace. In case of the legs, neck folds, and plastron the skin was cast in small pieces, but the carapace skin was shed all at once (Fig. 2). The skin was completely casted in about 23 days (January 03-25, 2009).

In biology, moulting signifies the manner in which an animal routinely casts off a part of its body (often, but not always, an outer layer or covering), either at specific times of the year or at specific points in its life cycle.

Turtles and terrapins do not moult their skins all at once, as snakes do, but continuously in small pieces (Alderton 1986). Tortoises also shed skin, but a lot of dead skin is allowed to accumulate in thick knobs and plates that provide protection to parts of the body outside the shell (Gilbert *et al.* 2001).

This case of unusual shedding of the carapace of the flap-shell turtle may be due to the prolonged starvation and desiccation for eight months. The turtle may have developed calcium deficiency and the outer layer of the carapace came off in one single piece (Kaplan 2009).

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5. DOES THE GANGES SHARK *GLYPHIS GANGETICUS* STRAY TO SRI LANKA?

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Natural history journalist Malaka Rodrigo photographed some sharks at Negombo fish market on March 23, 2011. One of his images shows the anterior part of an 'unusual' shark, which I suspect could be the Ganges Shark *Glyphis gangeticus* (Fig. 1). As the photograph was insufficient in itself to positively identify the species, I forwarded the image to the Shark Research Institute and enquired if the fish could be a Ganges Shark. Dr. L.J.V. Compagno, one of the World's leading authorities on sharks, responded "Possible, but it is necessary to check out the dentition and the dorsal fin proportions to confirm it". He further stated that it could also be one of the four other (named) species.

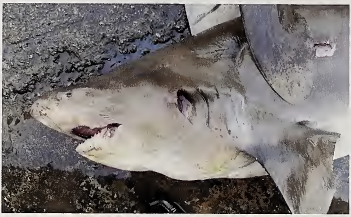

Fig. 1: Shark photographed in Negombo by Malaka Rodrigo

The shark is brownish dorsally, shading to grey laterally and whitish ventrally. The third, fourth and fifth gill slits are above the pectoral fin base (something common to a few other sharks as well). The snout is short and the eye is minute. The minute eye of this specimen is most likely a degenerate feature in a species, which probably spends most of its time in turbid waters, where sight is of limited value. The minute eye and what is visible of the teeth on the lower jaw are consistent with the Ganges Shark. The known range of the Ganges Shark is the Ganges and Hooghly river systems, and the turbid coastal waters along the east and west coasts of peninsular India down to about 9° 45' N. If the shark photographed in Negombo is a Ganges Shark (and this is not certain) it is probably a stray carried south of its normal range by ocean currents. The Ganges Shark has a reputation for being a ferocious man-eater (Coppleson 1962), although most attacks attributed to it are probably the result of confusion with the Bull Shark *Carcharhinus leucas*, a notorious man-eater, which also occurs in the Ganges and Hooghly river systems (Compagno 1984).

It is necessary to emphasize that the actual identity of the shark is uncertain at present. However, this may be a 'wake-up' call for ichthyologists to be on the alert for the Ganges Shark in Sri Lankan waters. If, and when, a specimen becomes available it will be useful to check out the dentition and proportions of the dorsal fin. Photographs showing a lateral view of the entire shark will be helpful. Ideally any specimen should be preserved for study.

ACKNOWLEDGEMENTS

I am grateful to Malaka Rodrigo for his image of the shark. I thank Dr. L.J.V. Compagno for his comments on the photograph and Professor S.W. Kotagama (University of Colombo) for reading the manuscript and offering constructive comments, which greatly improved this paper.

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6. REDESCRIPTION OF BATHYAL FISH *GLYPTOPHIDIUM MACROPUS* ALCOCK, 1894 FROM INDIAN EEZ (OPHIDIIFORMES: OPHIDIIDAE)

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The first authentic record of deep sea fishes from India was made by Alcock (1891) with the help of fishes collected by *R.I.M.S Investigator* in his book INDIAN DEEP SEA FISHES IN THE INDIAN MUSEUM. Investigation on the deep sea fishes of Indian Exclusive Economic Zone (EEZ) were mainly carried out by the Fisheries Survey of India, concentrating mostly in the continental shelf region. Hence, information regarding the Indian deep sea fish fauna is scarce and the only available data is from the fishing cruises of the Indian research ship *FORV Sagar Sampada*, as a part of its Stock Assessment Programme of deep sea fin and shell fishes. Recent research cruises of *FORV Sagar Sampada* have unearthed many little known deep sea fishes of Order Ophidiiformes unravelling the rich deep sea ichthyofaunal biodiversity of India.

Ophidiids are predominant members of deep sea demersal fishes from the continental slope to abyssal plain (Haedrich and Merrett 1988; Merrett and Haedrich 1997). The first catalogue of Ophidiiformes was published by Cohen and Nielsen (1978), which mainly focused on genus level while species classification is incomplete. Subsequently, Nielsen and Cohen (1999) published another catalogue that included all Ophidiiformes of the world, which included 48 genera and 218 species of deep sea fishes under Family Ophidiidae. Genus *Glyptophidium* has been revised by Nielsen and Machida (1988), which includes seven recognized species. The species fall into two well-defined species group: *argentium* species, which includes *G. argentium* Alcock, 1889, *G. effulgens* Nielsen & Machida, 1988 and *G. lucidum* Smith & Radcliffe, 1913 and *macropus* species, which includes the remaining four species, namely *G. macropus* Alcock, 1894, *G. longiceps* Norman, 1939, *G. oceanium* Smith & Radcliffe, 1913, and *G. japonium* Kamohara, 1936.

Glyptophidium collections landed by *FORV Sagar Sampada* were subjected to detailed taxonomic studies, which confirmed the identity of *G. macropus* Alcock, 1894. This species has not received much attention since its original description by Alcock (1894) from its type locality, Bay of Bengal. Hence, an attempt is also made to redescribe this deep sea fish by comparing its morphometrics and meristics with its lectotype and paralectotypes.

The present study was carried out as part of the Ministry of Earth Sciences (MoES), Government of India, funded research project on "Resource assessment and biology of deep sea fishes along the continental slope of Indian EEZ". The fishes were caught during cruise no: 250 of *FORV Sagar Sampada*, from station number 12 (12° 28' 2" N; 74° 09' 5" E) at a depth of 415 m on 8.xi.2006 (Fig. 1) using HSDT fish version (High Speed Demersal Trawl) net and identified following Nielsen and Machida (1988). Specimens were deposited in the Fish Museum of School of Industrial Fisheries (SIF), Cochin University of Science and Technology, India. Morphometric measurements were taken to the nearest millimetre using a dialed Vernier Caliper following Smith and Heemstra (1986). Body proportions were expressed in terms of standard length (SL: length from snout tip to the base of caudal fin) and head length (HL: length of snout tip to the

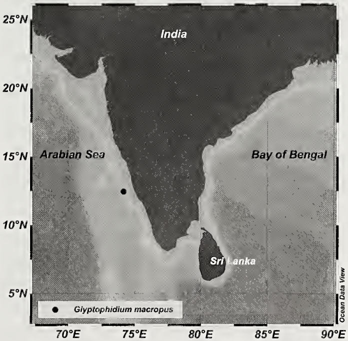

Fig. 1: Locality map of *Glyptophidium macropus* from the EEZ of India

posterior margin of opercle). Meristic counts were made following Nielsen and Machida (1988). Meristic counts and proportional measurements of *Glyptophidium macropus* with its lectotype and paralectotypes are given in Table 1. Measurements of the types were archived from Nielsen and Machida (1988).

Systematics

Order: Ophidiiformes Cohen & Nielsen, 1978
Suborder: Ophidioidei Cohen & Nielsen, 1978
Family: Ophidiidae Rafinesque, 1810
Subfamily: Neobythitinae Radcliffe, 1913
Genus: *Glyptophidium* Alcock, 1894
Glyptophidium macropus Alcock, 1894

Type material: *Glyptophidium macropus* Alcock, 1894:122, pl. VI, fig.3 (type locality: Bay of Bengal)

G. *macropus*: Alcock, 1895: pl. XV, fig.6 and 1899:94; Brauer, 1906: 303 (now referred to *longipes*); Zander, 1906: 166 (now referred to *longipes*); Norman, 1939: 77; Menon and Yazdani, 1968: 148; Cohen and Nielsen, 1978: 32;

Lectotype: ZSI 13534 (SL 128 mm, female, "Investigator" st.162 (13° 51' 12" N; 80° 28' 12" E) 265-458 m, trawl, 30.i.1984.

Paralectotypes: ZSI 13529-13533, 13535 (SL 81-125+ mm, 3 females + 3 males), same data as for lectotypes.

Material Examined: SIF250/GM1 (Fig. 2), 133.9 mm SL, off Mangalore, SW coast of India, 12° 28' 2" N and 74° 09' 5" E, HSDT net, 415 m, 8.xi.2006.

Diagnosis: *G. macropus* differs from other species in the *macropus* species group by the following combinations of characters: developed gill rakers 36-41, basibranchial with two median and a pair of tooth patches and 2 rays in each ventral fin.

Description: Origin of dorsal fin close to head; in front of the anterior vertebrae, dorsal fin rays 2-3 times as long as corresponding anal fin rays; pectoral fins placed below midline of body; 2 rays in each ventral fin; caudal fin small with 9 rays. Cycloid scale, deciduous, head scale less. Lateral line indistinct. Mouth large with maxillary reaching posterior margin of orbit, numerous granular rows of teeth in irregular rows in dentary, premaxillary, vomer and palatine. Vomerine teeth somewhat longer than those on other bones, dentigerous part V-formed. Distinct nostril placed midway between upper lip and orbit; posterior nostril larger. Basibranchial with two median and a pair of tooth patches, the latter overlapping or free of anterior median patch (Fig. 4). Anterior gill arch with many long rakers, the longest of which are 2-3 times length of gill filaments (Fig. 3). Pseudobranchial filaments 7-8.

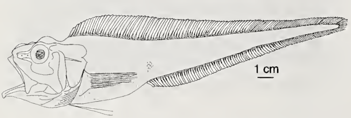

Fig. 2: Lateral view of *Glyptophidium macropus*

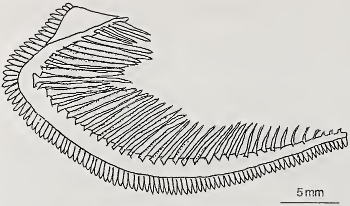

Fig. 3: Gill rakers of *Glyptophidium macropus*

Relationship: The closest related species is *G. longipes* with which it shares the following characters: long ventral fin rays (100-200% of length of head) and few pseudobranchial

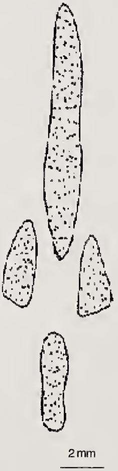

Fig. 4: Basibranchial tooth patch of *Glyptophidium macropus*

Table 1: Meristic counts and proportional measurements of *Glyptophidium macropus* with its lectotype and paralectotypes

Locality Depth (m)	Lectotype ZSI 13534 Bay of Bengal 265-458	Paralectotype (6 specimen) Bay of Bengal 265-458	SIF250/GM1 Off Mangalore 415
TL (mm)	-	-	144
SL (mm)	128	81-125+	133.9
In % of SL			
Body depth	-	-	27.1
Head depth	-	-	20.1
Head length (HL)	25	24-25.5	27.6
Depth at dorsal fin	19.5	20.5	22.5
Depth at anal fin	13.5	13.5	15.7
Preanal length	38.5	34.5-39.5	44.3
Predorsal length	19.0	20	18.7
Prepectoral length	-	-	30.0
Prepelvic length	-	-	24.3
Dorsal fin base	-	-	80.6
Anal fin base	-	-	48.9
Pectoral fin length	-	-	20.2
Pelvic fin length	-	-	18.6
Eye length	7.0	5.9-6.4	8.2
Post orbital length	13.5	13.0	13.0
In % of HL			
Preorbital length	-	-	29.0
Postorbital length	-	-	42.9
Inter orbital width	-	-	25.4
Diameter of horizontal orbit	-	-	14.0
Eye length	28.0	24.5-27.0	27.0
Depth at eye	-	-	25.5
Upper jaw length	-	-	46.1
Depth at maxillary end	-	-	15.3
Depth at dorsal fin	72.0	80.0	73.1
Depth at anal fin	55.0	53	55.0
In % of preanal length			
Head length	65	61-70	64.7
Counts			
Dorsal fin rays	119	118-119	116
Anal fin rays	90	91-98	88
Caudal fin rays	9	9	9
Pectoral fin rays	24	24	24
Pelvic fin rays	2	2	2
Branchiostegal rays	-	-	10
Pseudobranchial filament	9	7-8	8
Gill rakers	38	37-41	42
Developed gill rakers	37	36-41	41
Anterior anal ray below dorsal ray number	31	29-32	32

Source: Nielsen and Machida (1988)

filaments (8). It differs from *G. longipes* by having more pectoral fin rays (24 vs. 20-23), more caudal fin rays (9 vs. 7-8), larger orbit (14 vs. 4.6- 5.6% SL) and psuedobranchial filament with light stem (vs. dark stem).

Distribution: *G. macropus* is reported from northern Indian Ocean from the Gulf of Aden to off Sumatra and off Lombok. All specimens were taken in bottom trawls between 40 and 549 m depth.

Remarks: Most of the morphometric measurements in terms of % TL and SL of the SIF 250/GM1 was compared with that of the lectotype and paralectotypes. Depth at dorsal fin and anal fin, preanal length, predorsal length, post orbital length in % SL were found to be in the close range (Table 1). These measurements were also agreeing with the materials studied by Nielsen and Machida (1988). Few measurements such as post orbital length in % SL and depth at anal fin in % HL were almost the same (13-13.5 and 55 respectively) when compared with the lectotype and paralectotypes. Besides, counts of caudal fin, pectoral fin and pelvic fin support with the types and also concur with Nielsen and Machida (1988) materials. The morphometrics and meristics clearly confirm that SIF 250/GM1 is *G. macropus*. The species has been recorded first by Alcock in 1894 from Bay of Bengal. Since then it has not received much attention until 1988 when Nielsen and Machida made a revision of bathyal fishes under the genus *Glyptophidium*. The present redescription of this fish may also strengthen the rich deep sea ichthyofaunal biodiversity of the EEZ of India, and confirms the occurrence of the species in both the coast of India.

ACKNOWLEDGEMENTS

Scientific teams and Officers of cruise no: 250 of *FORV Sagar Sampada* are duly thanked. We are grateful to Dr. Doi Wataru, Post-doctoral Fellow of Tokyo University of Marine Science & Technology, for making available the references for the study. The financial assistance from the Ministry of Earth Sciences (MoES), Government of India, is acknowledged.

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7. AN ADDITIONAL RECORD OF LARVAL HOST PLANT OF TAWNY COSTER *ACRAEA VIOLAE* (FABRICIUS 1775)

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Tawny Coster *Acraea violae* is a common nymphalid found in forest clearings, open country and gardens (Kunte 2000; Kehimkar 2008). During a faunal survey at Mazgaon, (18° 21' 58.66" N; 72° 55' 58.73" E; 14 m above msl) Taluka Murud-Janjira, District Raigad, Maharashtra, on January 13, 2010, we observed larvae of different instars of Tawny Coster feeding on a small shrub *Turnera ulmifolia* L., which is commonly known as 'Yellow Alder', belonging to Family Turneraceae. *Turnera ulmifolia* L. is a common cultivated plant about 1 m in height, stem erect, branches glandular pubescent. It occasionally occurs in scrub forests of Konkan (Ingalhalikar 2001).

The perusal of literature elucidate that the *Turnera ulmifolia* is an unreported host plant for Tawny Coster (Table 1). Family Turneraceae is an additional host plant family taking the total to ten for Tawny Coster.

The larva only feeds on leaves and starts eating it in an arc length from the margins up to the mid-rib. *Turnera ulmifolia* is known for cyanogenesis (ability of plants to liberate hydrogen cyanide (HCN) when damaged). Schappert and Shore (1999) on Jamaica have studied the relationship of *Turnera ulmifolia* and *Euptoieta hegesia* in the context of cyanogenesis, herbivory and plant defence. Further research is needed to determine the effect of herbivory of Tawny Coster on *Turnera ulmifolia*. This observation is also particularly important as *Turnera ulmifolia* is an invasive alien species in India. It is interesting to know whether it is possible to use Tawny Coster to control invasion of *Turnera ulmifolia* in future.

Though we report *Turnera ulmifolia* as a host plant for the Tawny Coster *Acraea violae* in India, Robinson *et al.* (2010) reported two more nymphalid butterfly species feeding on *Turnera ulmifolia* in other parts of the world (Table 2).

Table 1: The account of known larval host plants of Tawny Coster according to different authors is given

Sr. No.	Host plants	Family	Authors
1	*Adenia hondala* (=*Modecca palmata*)	Passifloraceae	Wynter-Blyth 1957, Gunathilagaraj *et al.* 1998, Kunte 2000, Robinson *et al.* 2010, Parasharya and Jani 2007, Kehimkar 2008
2	*Passiflora foetida*		Wynter-Blyth 1957, Kunte 2000, Robinson *et al.* 2010, Parasharya and Jani 2007, Kehimkar 2008
3	*Passiflora edulis*		Kunte 2000, Robinson *et al.* 2010, Parasharya and Jani 2007, Kehimkar 2008
4	*Passiflora subpeltata*		Kunte 2000, Robinson *et al.* 2010, Parasharya and Jani 2007, Kehimkar 2008
5	*Passiflora* spp.		Gay *et al.* 1992, Gay *et al.* 2008, Gunathilagaraj *et al.* 1998
6	*Aposora lindleyana*	Euphorbiaceae	Kehimkar 2008
7	*Mangifera indica*	Anacardiaceae	Gunathilagaraj *et al.* 1998
8	*Musa* spp.	Musaceae	Gunathilagaraj *et al.* 1998
9	*Hybanthus enneaspermus*	Violaceae	Das *et al.* 2010
10	*Hibiscus cannabinus*	Malvaceae	Wynter-Blyth 1957
11	*Hibiscus* spp.		Gunathilagaraj *et al.* 1998
12	Members of the Family Cucurbitaceae	Cucurbitaceae	Wynter-Blyth 1957, Satyamurti 1966, Gay *et al.* 1992, 2008
13	Members of the Family Urticaceae	Urticaceae	Gunathilagaraj *et al.* 1998

Table 2: Other butterfly species recorded feeding on *Turnera ulmifolia* in rest of the world

Butterfly Species	Plant Species	Region
Euptoieta claudia	*Turnera ulmifolia*	Cuba
Euptoieta claudia	*Turnera ulmifolia*	New World
Euptoieta hegesia	*Turnera ulmifolia*	Central America
Euptoieta hegesia	*Turnera ulmifolia*	Puerto Rico

(Robinson *et al.* 2010)

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8. AN ANNOTATED REPORT OF MITES INFESTING MEDICINAL PLANTS OF WEST BENGAL, INDIA

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Introduction

Mites, taxonomically grouped as Acari, are responsible for infesting timber, fruits, crops, tea and vegetables, stored grains and ornamental as well as medicinal plants, and thus act as pest in many instances (Chhillar *et al.* 2007). Little work has been done in India in general, and West Bengal in particular, on mite fauna of conventional medicinal plants; the available works are of Lal and Mukherjee (1977) from Uttar Pradesh, Sadana *et al.* (1981) from Punjab, Ghosh (2004) from Arunachal Pradesh, Rolania and Sharma (2008) from Rajasthan, Ghosh and Gupta (2003), Lahiri *et al.* (2004, 2005), and Gupta (2005) from West Bengal. In recent past, Roy *et al.* (2006, 2008a, b, c, 2009, 2010), and Roy and Saha (2010) have made substantial contribution on different aspects of mites infesting medicinal plants of West Bengal.

Collection of mites for taxonomic study

A systematic survey was conducted between January 2004 and December 2008 at different medicinal plant gardens and wilderness situated in different districts of West Bengal. The districts surveyed were Darjeeling, Jalpaiguri, Cooch Behar, Bardhawan, Medinipur (West), Medinipur (East), Howrah, Hooghly, Purulia, Nadia, 24-Parganas (North), 24-Parganas (South) and Kolkata. During sampling, leaves and other parts such as stem, barks, buds of different medicinal plants were observed minutely with magnifying glass and infested leaves were plucked and placed in plastic sachet (< 0.2 micron thickness) and labelled as suggested by Faraji *et al.* (2004). The leaves and the polythene bags were further checked under a stereozoom binocular in a laboratory to note the presence of mite, if any. Though aphids, ants, beetles, and bugs were noted from the collected samples, data on only mites were considered for the present study. After counting the mites on the infested plant parts, all specimens of phytophagous and predatory mites were preserved in 70% ethyl alcohol using fine sable hairbrush for further taxonomic studies.

The infested medicinal plants collected were identified with assistance from the Department of Botany, University of Calcutta, and herbarium collection of Ramakrishna Mission Ashrama, Narendrapur, Kolkata. The scientific names of the plants used in the present research work are based on Das and Mandal (2003) and Paria (2005).

Preparation of slides and identification of mite species

Temporary slides were prepared using lactic acid (50%) and permanent slides were made using Hoyer's medium (Krantz 1978). Specimens were identified using a light microscope and comparing with published descriptions and illustrations without recourse to type specimens. Available literature like Gupta (1985, 1987, 2002, 2003), Gupta and Gupta (1994), Bhattacharyya *et al.* (2000), Mohanasundaram (2001) and Chaudhury (2009) was followed. Classification of phytoseiids mites used in this paper is that of Chant and McMurtry (1994, 2007). The slide containing specimens, including holotypes are at present kept in the Entomology and Wildlife Biology Research Laboratory, Department of Zoology, University of Calcutta.

Results and Discussion

A total of 99 species of mites, belonging to 40 genera and 17 families under 3 orders were observed during the entire study period. Among these, 33 phytophagous mite species belonging to 12 genera and 4 families (Table 1a) and 66 predatory mite species belonging to 28 genera and 13 families (Table 1b) were found to occur in different districts of West Bengal infesting more than 80 species of medicinal plants. The present study includes new reports of 25 species of phytophagous mites from their respective host plants and 27 species of predatory mites for the first time from their respective habitat. Among phytophagous mites, the predominant genera were *Brevipalpus*, represented by 10 species, followed by *Tetranychus*, represented by 8 species. *Tetranychus urticae* was recorded from maximum, i.e. 7 different host plants followed by *Eutetranychus orientalis* and *Tetranychus ludeni* which were isolated from 4 and 3 different host plants, respectively. Among predatory mites, the genus *Euseius* is predominant represented by 8 species, followed by *Agistemus*, *Amblyseius* and *Phytoseius*

Table 1: List of mite species recorded during 2004-2008 from different medicinal plants in different districts of West Bengal

(a) List of phytophagous mite species:

Mite species	Host plant/ habitat	District	Remarks
Order I. PROSTIGMATA			
Family 1. TETRANYCHIDAE Donnadieu			
Genus 1. *Petrobia* Murray			
1. *Petrobia* (*Tetranychina*) *harti* (Ewing)	*Oxalis corniculata* Linn.	Kolkata & 24-Parganas (S)	
Genus 2. *Eutetranychus* Banks			
2. *Eutetranychus caricae* Nassar & Ghai	*Ficus carica* L.	Kolkata & 24-Parganas (S)	
3. *E. orientalis* (Klein)	*Aegle marmelos* (L.) Corr. ex Roxb., *Carica papaya* L., *Withania somnifera* Dunal, *Datura metel* Linn.	Kolkata & 24-Parganas (S), Bardhawan	New record on *Datura metel*
Genus 3. *Eotetranychus* Oudemans			
4. *Eotetranychus* sp.	*Murraya koenigii* (L.) Spreng.	Kolkata & 24-Parganas (S)	
Genus 4. *Oligonychus* Berlese			
5. *Oligonychus biharensis* (Hirst)	*Datura metel* Linn.	Hooghly	New record on this host
6. *O. indicus* (Hirst)	*Musa paradisiaca* L., *Cocos nucifera* L., *Saccharum officinarum* L.	Howrah, Kolkata & 24-Parganas (S)	New record on *Cocos nucifera*
7. *O. oryzae* (Hirst)	*Cymbopogon winterianus* Jawitt	Kolkata & 24-Parganas (S)	
Genus 5. *Panonychus* Yokoyama			
8. *Panonychus citri* (McGregor)	*Crateva nurvala* Buch.-Ham, *Carica papaya* L.	Kolkata & 24-Parganas (S)	New record on *Crateva nurvala*
Genus 6. *Schizotetranychus* Trägardh			
9 *Schizotetranychus baltazari* Rimando	*Murraya koenigii* (L.) Spreng., *Curcuma zedoaria* Rosc.	Kolkata & 24-Parganas (S)	New record on *Curcuma zedoaria*
10. *S. cajani* Gupta	*Murraya koenigii* (L.) Spreng. *Indigofera tinctoria* Linn., *Cymbopogon martini* (Roxb.) Watt., *Phyllanthus fraternus* Webster	Kolkata & 24-Parganas (S)	New record on *Murraya koenigii* and *Phyllanthus fraternus*
11. *S. hindustanicus* (Hirst)	*Murraya koenigii* (L.) Spreng.	Kolkata & 24-Parganas (S)	
Genus 7. *Tetranychus* Dufour			
12. *Tetranychus cinnabarinus* (Boisd.)	*Datura metel* Linn.	Darjeeling	New record on this host
13. *T. fijiensis* Hirst	*Pongamia pinnata* (L.) Pierre	Kolkata & 24-Parganas (S)	New record on this host
14. *T. hydrangeae* Pritchard & Baker	*Datura innoxia* Mill.	Hooghly	New record on this host
15. *T. ludeni* Zacher	*Abutilon indicum* (L.) Sweet, *Tinospora cordifolia* (Willd.) Hook.f. & Thoms., *Datura metel* Linn.	Kolkata & 24-Parganas (S); Medinipur (W)	New record on *Abutilon indicum* and *Tinospora cordifolia*
16 *T. macfarlanei* Baker & Pritchard	*Withania somnifera* (L.) Dunal	Jalpaiguri	
17. *T. neocaledonicus* André	*Withania somnifera* (L.) Dunal, *Abelmoschus moschatus* Medik., *Leucas plukenetii* (Roth.) Spreng.	Kolkata & 24-Parganas (S), Medinipur (W)	New record on *Withania somnifera* and *Leucas plukenetii*
18. *T. urticae* Koch	*Aristolochia indica* Linn., *Withania somnifera* Dunal, *Justicia adhatoda* Linn., *Datura metel* Linn., *Murraya koenigii* (L.) Spreng., *Ocimum sanctum* Linn., *Sida rhombifolia* Linn.	Darjeeling, Kolkata & 24-Parganas (S) Hooghly	New record on *Sida rhombifolia*

Table 1: List of mite species recorded during 2004-2008 from different medicinal plants in different districts of West Bengal (*contd.*)

(a) List of phytophagous mite species: (*contd.*)

Mite species	Host plant/ habitat	District	Remarks
19. *Tetranychus* sp.	*Hibiscus vitifolius* Linn.	Hooghly	Species identification not possible for want of male species
Family 2. TENUIPALPIDAE Berlese			
Genus 8. *Brevipalpus* Donnadieu			
20. *Brevipalpus californicus* (Banks)	*Alstonia scholaris* (L.) R. Br., *Cassia alata* Linn., *Murraya koenigii* (L.) Spreng.	Kolkata & 24-Parganas (S)	New record on these hosts
21. *B. chilensis* Baker	*Azadirachta indica* Juss.	Purulia	New record on this host
22. *B. cucurbitae* Mohansundaram	*Ricinus communis* Linn., *Murraya koenigii* (L.) Spreng.	Cooch Behar 24-Parganas (S)	New record on this host
23. *B. deleoni* Pritchard & Baker	*Ocimum gratissimum* Linn.	Kolkata & 24-Parganas (S)	New record on this hosts
24. *B. essigi* Baker	*Ocimum gratissimum* Linn.	Kolkata & 24-Parganas (S)	New record on this host
25. *B. euphorbiae* Mohansundaram	*Terminalia chebula* Retz.	Jalpaiguri	New record on this host
26. *B. karachiensis* Chaudhri, Akbar & Rasool	*Ocimum sanctum* Linn. *Ocimum basilicum* Linn.	Kolkata & 24-Parganas (S), Medinipur (W).	
27. *B. obovatus* Donnadieu	*Clerodendrum indicum* (L.) O. Kuntze, *Desmodium gangeticum* DC.	Kolkata & 24-Parganas (S), Medinipur (W)	New record on *Clerodendrum indicum*
28. *B. phoenicis* (Geij)	*Acacia catechu* (L.f.) Willd., *Ocimum gratissimum* Linn.	Howrah Kolkata & 24-Parganas (S)	New record on this host
29. *B. rugulosus* Chaudhri, Akbar & Rasool	*Justicia adhatoda* Linn.	Jalpaiguri	New record on these hosts
Family 3. ERIOPHYIDAE Nalepa			
Genus 9. *Aceria* Keifer			
30. *Aceria clerodendronis* Farkas	*Clerodendrum viscosum* Vent.	Howrah	
Genus 10. *Calepitrimerus* Keifer			
31. *Calepitrimerus azadirachtae* ChannaBasavanna	*Azadirachta indica* A. Juss	Medinipur (W)	
Genus 11. *Paratetra* ChannaBasavanna			
32. *Paratetra murrayae* ChannaBasavanna	*Murraya koenigii* (L.) Spreng.	Kolkata & 24-Parganas (S)	
Family 4. TARSONEMIDAE Kramer			
Genus 12. *Polyphagotarsonemus* Beer & Nucifora			
33. *Polyphagotarsonemus latus* (Banks)	*Withania somnifera* (L.) Dunal, *Ocimum sanctum* Linn.	Kolkata & 24-Parganas (S)	

(b) List of predatory mite species:

Mite species	Host plant/ habitat	District	Remarks
Order I. PROSTIGMATA			
Family 5. ANYSTIDAE Oudemans			
Genus 13. *Anystis* von Heyden			
34. *Anystis baccarum* (Linnaeus)	*Cinchona officinalis* Linn.	Darjeeling	
Family 6. BDELLIDAE Duges			
Genus 14. *Bdellodes* Oudemans			
35. *Bdellodes augusta* Roy and Saha	*Ambroma augusta* (L.) L.f.	Kolkata & 24-Parganas (S)	New species, already published

Table 1: List of mite species recorded during 2004-2008 from different medicinal plants in different districts of West Bengal (*contd.*)

(b) List of predatory mite species: (*contd.*)

Mite species	Host plant/ habitat	District	Remarks
36. *B. manipurensis* Gupta	*Andrographis paniculata* (Burm. f.) Wall. ex Nees	Kolkata & 24-Parganas (S)	New record on this habitat
Family 7. CHEYLETIDAE Leach			
Genus 15. *Chelacaropsis* Baker			
37. *Chelacaropsis moorei* Baker	*Nyctanthes arbor-tristis* Linn.	Kolkata & 24-Parganas (S)	New record on this habitat
Family 8. CUNAXIDAE Thor			
Genus 16. *Cunaxa* von Heyden			
38. *Cunaxa mangiferae* Gupta	*Carica papaya* L.	Kolkata & 24-Parganas (S)	
39. *C. myabunderensis* Gupta and Ghosh	*Zingiber* sp.	Darjeeling	
40. *C. setirostris* (Hermann)	*Ficus glomerata* Roxb., *Ocimum gratissimum* L., *Withania somnifera* (L.) Dunal	Kolkata & 24-Parganas (S)	New record on *Ocimum gratissimum* and *Withania somnifera*
41. *C. womersleyi* Baker & Hoffmann	*Datura metel* Linn., *Bauhinia acuminata* Linn., *Ocimum sanctum* Linn.	Kolkata & 24-Parganas (S), Howrah, Darjeeling	
Genus 17. *Neocunaxoides* Smiley			
42. *Neocunaxoides* sp.	*Clerodendrum viscosum* Vent.	Howrah	
Family 9. ERYTHRAEIDAE Robineau-Desvoidy			
Genus 18. *Erythraeus* Latreille			
43. *Erythraeus cinchoni* Roy *et al.*	*Cinchona officinalis* Linn.	Darjeeling	New species, already published out of this work
Family 10. RAPHIGNATHIDAE Kramer			
Genus 19. *Exothorhis* Summers			
44. *Exothorhis justicia* Roy *et al.*	*Justicia adhatoda* Linn.	Kolkata & 24-Parganas (S)	New species, already published out of this work
Family 11. EUPODIDAE Koch			
Genus 20. *Eupodes* Koch			
45. *Eupodes sigmoidensis* Strandtmann and Goff	*Acacia* sp.	Kolkata & 24-Parganas (S)	
Family 12. STIGMAEIDAE Oudemans			
Genus 21. *Agistemus* Summers			
46. *Agistemus albae* Roy *et al.*	*Morus alba* Linn.	Darjeeling	New species, already published out of this work
47. *A. edulis* Gupta	*Mangifera indica* Linn.	Kolkata & 24-Parganas (S)	
48. *A. fleschneri* Summers	*Desmodium gangeticum* (L.) DC, *Gymnema sylvestre* (Retz.) R. Br. ex Schult, *Justicia adhatoda* Linn.	Midnapore (W), Hooghly, Kolkata & 24-Parganas (S);	New record from these habitats
49. *A. lobata* Roy *et al.*	*Urena lobata* Linn.	Kolkata & 24-Parganas (S)	New species, already published out of this work.
50. *A. simplex* Gonzalez-Rodriguez	*Zingiber* sp.	Darjeeling	
51. *A. terminalis* (Quayle)	*Dioscorea* sp.	Jalpaiguri	
52. *A. unguiparvus* Gonzalez Rodriguez	*Aristolochia indica* Linn.	Darjeeling	

Table 1: List of mite species recorded during 2004-2008 from different medicinal plants in different districts of West Bengal (*contd.*)

(b) List of predatory mite species: (*contd.*)

Mite species	Host plant/ habitat	District	Remarks
Family 13. TYDEIDAE Kramer			
Genus 22. *Lorryia* Oudemans			
53. *Lorryia* sp.	*Terminalia myriocarpa* Van Heurck & Müll. Arg.	Darjeeling	
Genus 23. *Parapronematus* Baker			
54. *Parapronematus murshidabadensis* Gupta	*Alstonia scholaris* (L.) R. Br., *Cassia alata* Linn., *Crateva nurvala* Buch.-Ham.	Kolkata & 24-Parganas (S), Medinipur	New record on *Crateva nurvala*
Genus 24. *Pronematus* Canestrini			
55. *Pronematus fleschneri* Baker	*Pterocarpus santalinus* Linn.f.	Kolkata & 24-Parganas (S)	New record on this habitat
56. *P. sextoni* Baker	*Bauhinia acuminata* Linn.	Howrah	
Genus 25. *Tydeus* Koch			
57. *Tydeus cumini* Gupta	*Thevetia neriifolia* Juss. ex Steud, *Ficus carica* L.	Howrah, Purulia	New record on this habitat
58. *T. justicia* Roy *et al.*	*Justicia adhatoda* Linn.	Kolkata & 24-Parganas (S)	New species, already published
59. *Tydeus* sp.	*Ficus* sp.	Kolkata	Could not be identified due to damaged condition
Order II. ASTIGMATA Canestrini			
Family 14. ACARIDAE Ewing & Nesbitt			
Genus 26. *Acarus* Linnaeus			
60. *Acarus farris* Oudemans	*Datura metel* Linn.	Kolkata & 24-Parganas (S)	New record on this habitat
Genus 27. *Caloglyphus*			
61. *Caloglyphus rhizoglyphoides* (Zachvatkin)	*Gossypium herbaceum* Linn.	Kolkata & 24-Parganas (S)	New record on this habitat
Genus 28. *Tyrophagus* Oudemans			
62. *Tyrophagus putrescentiae* (Schrank)	*Solanum nigrum* Linn., *Justicia adhatoda* Linn.	Kolkata & 24-Parganas (S)	New record on these habitats
Family 15. AMEROSEIIDAE			
Genus 29. *Kleemannia* Oudemans			
63. *Kleemannia plumigera* Oudemans	*Alstonia scholaris* (L.) R. Br.	Kolkata & 24-Parganas (S)	New record on this habitat.
Order III. MESOSTIGMATA			
Family 16. ASCIDAE Voigts & Oudemans			
Genus 30. *Lasioseius* Berlese			
64. *Lasioseius phytoseioides* Chant	*Alstonia scholaris* (L.) R. Br.	24-Parganas (N)	New record on this habitat
65. *L. quadrisetosus* Chant	*Nyctanthes arbor-tristis* Linn.	24-Parganas (N)	New record on this habitat
66. *L. terrestris* Menon & Ghai	*Boerhavia diffusa* Linn., *Datura metel* Linn.	Kolkata & 24-Parganas (S), Nadia	New record on this habitat
67. *Lasioseius* sp.	*Alstonia scholaris* (Linn.) R. Br.	Kolkata & 24-Parganas (S)	New record on this habitat, Could not be identified due to damaged condition
Family 17. PHYTOSEIIDAE Berlese			
Genus 31. *Amblyseius* Berlese			
68. *Amblyseius aerialis* (Muma)	*Clerodendrum siphonanthus* R. Br.	Darjeeling	

Table 1: List of mite species recorded during 2004-2008 from different medicinal plants at different Districts of West Bengal (*contd.*)

(b) List of predatory mite species: (*contd.*)

Mite species	Host plant/ habitat	District	Remarks
69. *A. channabasavannai* Gupta	*Ambroma augusta* (Linn.) L.f	Kolkata & 24-Parganas (S) Medinipur (West)	
70. *A. cucurbitae* Rather	*Nyctanthes arbor-tristis* Linn.	24-Parganas (North)	New record on this habitat
71. *A. herbicolus* (Chant)	*Cinchona officinalis* Linn., *Coccinia indica* W.A.	Darjeeling, Kolkata & 24-Parganas (S)	
72. *A. kulini* Gupta	*Murraya koenigii* (L.) Spreng.	Kolkata & 24-Parganas (S)	
73. *A. largoensis* (Muma)	*Aristolochia indica* Linn. *Gymnema sylvestre* (Retz.) R. Br. ex Schuit, *Aegle marmelos* (L.) Corr. ex Roxb. *Alstonia scholaris* R. Br. *Azadirachta indica* A. Juss. *Boerhavia diffusa* Linn. *Carica papaya* L. *Curcuma zedoaria* Rosc. *Justicia adhatoda* Linn.	Darjeeling Hooghly, Cooch Behar Jalpaiguri, Purulia, Nadia, Kolkata, & 24-Parganas (S)	New habitat records on *Aegle marmelos*, *Alstonia scholaris*, *Curcuma zedoaria*
74. *A. paraaerialis* Muma	*Acacia catechu* (L.f.) Willd. *Carica papaya* L.	Kolkata & 24-Parganas (S)	New record from habitat *Acacia catechu*
Genus 32. *Euseius* Wainstein			
75. *Euseius alstonae* (Gupta)	*Aegle marmelos* (L.) Corr. ex Roxb., *Alstonia scholaris* R. Br., *Cassia alata* Linn.	Hooghly, Kolkata & 24-Parganas (S)	
76. *E. coccineae* (Gupta)	*Morus alba* Linn.	Darjeeling	
77. *E. coccosocius* (Ghai & Menon)	*Desmodium motorium* (Houtt.) Merril	Darjeeling	
78. *E. eucalypti* (Ghai & Menon)	*Coccinia grandis* (Linn.) Voigt	24-Parganas (North)	New record from habitat
79. *E. finlandicus* (Oudemans)	*Quercus incana* Roxb., *Justicia adhatoda* Linn.	Darjeeling, Kolkata & 24-Parganas (S)	New record from habitat
80. *E. macrospatulatus* (Gupta)	*Tinospora cordifolia* (Willd.) Hook.f. & Thoms.	Nadia	
81. *E. ovalis* (Evans)	*Aegle marmelos* (L.) Corr. ex Roxb.	Kolkata & 24-Parganas (S)	
82. *E. pruni* (Gupa)	*Clematis buchananian* DC	Darjeeling	
Genus 33. *Neoseiulus* Hughes			
83. *Neoseiulus longispinosus* (Evans)	*Oroxylum indicum* Vent., *Datura metel* Linn., *Carica papaya* L.	Purulia, Kolkata & 24-Parganas (S)	New habitat record from *Oroxylum indicum*
Genus 34. *Paraphytoseius* Swirski & Schecter			
84. *Paraphytoseius multidentatus* (Swirski and Shechter)	*Ambroma augusta* (Linn.) L.f., *Ocimum sanctum* Linn., *Ficus carica* L.	Midnapore, Kolkata & 24-Parganas (S)	
Genus 35. *Proprioseiopsis* Muma			
85. *Proprioseiopsis peltatus* (Van der Merwe)	*Nyctanthes arbor-tristis* Linn.	Kolkata & 24-Parganas (S)	New record from habitat
Genus 36. *Typhlodromips* De Leon			
86. *Typhlodromips suknaensis* (Gupta)	*Barleria lupulina* Lindl., *Datura metel* Linn., *Murraya koenigii* (L.) Spreng.	Kolkata & 24-Parganas (S)	New habitat record from *Barleria lupulina*

Table 1: List of mite species recorded during 2004-2008 from different medicinal plants in different districts of West Bengal (*contd.*)

(b) List of predatory mite species: (*contd.*)

Mite species	Host plant/ habitat	District	Remarks
87. *T. syzygii* (Gupta)	*Abelmoschus moschatus* Medik., *Asteracantha longifolia* (L.) Nees	Medinipur, Kolkata & 24-Parganas (S)	New record on *Asteracantha longifolia*
Genus 37. *Gynaeseius* Wainstein			
88. *Gynaeseius eharai* (Gupta)	*Nerium indicum* L.	Kolkata	
89. *Gynaeseius* sp.	*Aristolochia indica* Linn.	Darjeeling	
Genus 38. *Iphiseius* Berlese			
90. *Iphiseius* (*Trochoseius*) *augusta* Roy *et al.*	*Ambroma augusta* L.f.	Kolkata & 24-Parganas (S)	New species, already published out of this work
Genus 39. *Phytoseius* Ribaga			
91. *Phytoseius intermedius* Evans & Macfarlane	*Clerodendrum viscosum* Vent.	Howrah	New record from habitat
92. *P. kapuri* Gupta	*Ficus* sp.	Howrah	New record from habitat
93. *P. maldahensis* Gupta	*Zingiber* sp.	Darjeeling	
94. *P. mizoramensis* Gupta & Chatterjee	*Clerodendrum viscosum* Vent.	Howrah	
95. *P. neocorniger* Gupta	*Abelmoschus moschatus* Medik.	Howrah	
96. *P. viscosum* Roy & Saha	*Clerodendrum viscosum* Vent.	Howrah	New species, already published out of this work
Genus 40. *Typhlodromus* Scheuten			
97. *Typhlodromus* (*Amblydromella*) *himalayensis* Gupta	*Clematis buchananian* DC	Darjeeling	
98. *T. (A.) homalii* Gupta	*Aegle marmelos* (L.) Corr. ex Roxb.	Kolkata & 24-Parganas (S)	
99. *Typhlodromus (Anthoseius) majumderi* Gupta	*Ficus glomerata* Roxb.	Kolkata & 24-Parganas (S)	New record from habitat

represented by 7, 7 and 6 species, respectively. *Amblyseius largoensis* and *Paraphytoseius multidentatus* were recorded as most abundant as well as efficient predators. During collection a total of 12 species were observed as most seriously infesting medicinal plants doing considerable damage (Table 2).

The present research documents a pioneer initiative in the study area covering 14 out of 19 districts of West Bengal, India, and incorporates broad survey and appraisal of more than 80 different medicinal plants for evaluation of mite infestations. Earlier a number of regional and fragmented

Table 2: List of most injurious mites along with their hosts and pertaining damage symptoms

Mite Species	Host Plant	Nature of damage
Petrobia (*Tetranychina*) *harti* (Ewing)	*Oxalis corniculata* Linn.	Infested leaves turn initially yellow, later brown and and finally dry up.
Tetranychus hydrangeae Pritchard & Baker	*Datura innoxia* Mill.	Infested leaves develop white patches at the points of infestation which later turn brown and leaves wither.
Tetranychus ludeni Zacher	*Abutilon indicum* (Linn.) Sweet, *Clitoria ternatea* Linn., *Tinospora cordifolia* (Willd.) Hook.f. & Thoms.	Infested leaves turn yellow, dry up and fall off.
Tetranychus neocaledonicus Andre	*Withania somnifera* (L.) Dunal *Leucas plukenetii* (Roth.) Spreng, *Justicia adhatoda* Linn.	Infested leaves show discolouration at the points of feeding giving yellow patches at later stage of infestation.
Tetranychus urticae Koch	*Withania somnifera* (L.) Dunal,	Appearance of yellowish spots on leaves. Later such leaves turn chocolaty brown and subsequently wither.
Oligonychus indicus (Hirst)	*Musa paradisiaca* Linn. *Cocos nucifera* Linn.	Feeding causes whitish patches on leaves.

Table 2: List of most injurious mites along with their hosts and pertaining damage symptoms (*contd.*)

Mite Species	Host Plant	Nature of damage
Oligonychus oryzae (Hirst)	*Cymbopogon winterianus* Jawitt	Leaves develop whitish patches at the points of feeding, later such leaves wither.
Schizotetranychus hindustanicus (Hirst)	*Murraya koenigii* (L.) Spreng.	Infested leaves become yellowish white mosaic spots.
Schizotetranychus cajani Gupta	*Murraya koenigii* (L.) Spreng.	Infested leaves become yellowish, smaller in size and later dry up.
Panonychus citri (McGregor)	*Carica papaya* Linn.	Infested leaves showed discolouration near petiole attachment.
Brevipalpus karachiensis Chaudhri, Akbar & Rasool	*Ocimum sanctum* Linn.	The infested leaves become pale yellow and later brownish spots appear at the points of feeding. Drying of leaves also observed.
Polyphagotarsonemus latus (Banks)	*Withania somnifera* (L.) Dunal	Leaves become curled and wrinkled, later such leaves wither.

studies have been made by several workers from India. Ghosh and Gupta (2003) and Lahiri *et al.* (2004) reported 54 and 51 species of mites infesting medicinal plants of West Bengal, respectively. Recently, from Darjeeling Himalayas, Roy *et al.* (2008b, c) recorded 24 species of mites infesting medicinal plants. Rolania and Sharma (2008) made a faunistic survey on mite pests infesting medicinal plants from Rajasthan. They recorded 4 phytophagous mites from 16 medicinal plants. The present study includes new reports of 21 species of phytophagous mites from their respective host plants and 27 species of predatory mites for the first time from their respective habitats. The results of the present study are expected to supplement the existing information on the pest status of mites on different medicinal plants apart from elaborating mite species diversity in the longitudinal biogeographical scale of West Bengal, India. Practically no record has been made from rest of the world about mite infestation on medicinal plants. These facts highlight a big lacuna in the study of mite fauna of conventional medicinal plants, and emphasize the need for a holistic approach towards this end. Further, the results will provide a basis for future work on mite-medicinal plant interactions and evaluation of strategic planning for management of medicinal plants and their utility.

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9. FIRST RECORD OF *LIOCHELES NIGRIPES* (POCOCK, 1897) (SCORPIONES: HEMISCORPIIDAE) FROM CHHATTISGARH, WITH COMMENTS ON ITS DISTRIBUTION

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Introduction

The scorpion family Hemiscorpiidae currently consists of approximately 12 genera and 93 species globally (Rein 2011). Members of the family are widely distributed throughout tropics and the subtropics of all continents.

The family was previously known as Ischnuridae, but due to nomenclatural conflict with Odonata subfamily (Ischnurinae) it was changed to Liochelidae. In 2005, Soleglad, Fet and Kovaøík included the genus *Heteroscorpion* in this family and renamed it Hemiscorpiidae, including in it all genera and species previously included in Liochelidae (Soleglad *et al.* 2005).

The family is distinguishable by the following set of characters: weak laterally compressed metasoma, tarsomere II of the legs in lateral view forming a right angle with claw base and 'C' type of trichobothrial pattern with only three ventral trichobothria on patella.

In India, Family Hemiscorpiidae is represented by three genera, namely *Lomachus*, *Chiromachetes* (endemic) and *Liocheles* comprising of eight species in all (Tikader and Bastawade 1983; Rein 2011).

Of these, genus *Liocheles* is widely distributed in Cameroon (probably imported), Australia, China, India, Indonesia, Laos, Malaysia, Myanmar and Vietnam. An explanation to its wide distribution is given by Polis (1990) … "The genus *Liocheles*, which hypothetically arose in India, secondarily invaded south-eastern Asia and Indonesia, and eventually Australia. Although Australia was a portion of Gondwanaland, it has been suggested that *Liocheles* dispersed there *via* land connections between south-eastern Asia and New Guinea, and between New Guinea and Australia at various times during the Cenozoic. This is supported by the fact that the three species of *Liocheles* in Australia are not endemic and are restricted to the north-eastern portion of that continent."

The genus currently comprises of at least six species of which two, namely *Liocheles nigripes* and *Liocheles australasiae* have been reported from India. Of these *Liocheles australasiae* is known only from the Andaman and Nicobar Islands, making *Liocheles nigripes* the sole representative of genus *Liocheles* from mainland India (Tikader and Bastawade 1983; Kovaøík and Fet 2006). Apart (*c*. 120 m above msl) and Almora, presently Uttarakhand (*c*. 1,642 m above msl; northernmost report) in India. Tikader and Bastawade (1983) report the species from only two localities, Panch Mahal and Udaipur (*c*. 598 m above msl), Rajasthan, India, without any citation of the other localities recorded by Caius (1942).

This communication deals with the first record of this species from the Indian state of Chhattisgarh based on a single female specimen collected from Kanger Valley National Park (KVNP), Bastar district, Chhattisgarh, and critically summarises its known distribution in India.

Methodology

The specimen was obtained while conducting a faunal survey of the Kanger Valley National Park. The individual was observed on a tree bark *c*. 0.6 m from the ground surface at 20:30 hrs on October 25, 2008. It was an identifiable member of the Hemiscorpiidae family (as per Tikader and Bastawade 1983). The specimen was caught and photographed; visible morphological characters and coloration were recorded before preserving it in 70% ethanol. The specimen was examined using a stereobinocular microscope and a digital calliper (nearest to 0.01 mm) was used to record morphometrics. Using keys given by Tikader and Bastawade (1983) and Kovaøík and Fet (2006) the specimen was identified as *Liocheles nigripes.*

The specimen is deposited in the collections of Bombay Natural History Society (BNHS) – registration number BNHS-Sc-20. The description of the collected specimen is as follows (trichobothriotaxy as per Vachon 1974):

Family: Hemiscorpiidae (Pocock 1893)
Genus: *Liocheles* (Sundewall 1833)
Liocheles nigripes (Pocock 1897)

Material examined: INDIA: Female (25.x.2008), Bhainsa Darra, Elevation: *c*. 552 m above msl, Kanger Valley National Park, Bastar district, Chhattisgarh. Collectors: Dharmendra Khandal, Sachin Rai, Sunny Patil and Ushma Shukla (BNHS-Sc-20). Morphometrics of the examined material are provided in Table 1.

Coloration in life: Carapace, mesosoma and metasoma dark brown; Pedipalps and legs dark brown to black. Chelicera pale brown, telson pale yellow. Pectines, basal piece and genetic operculum yellowish.

Prosoma: Carapace smooth, punctate, without carinae, medially depressed and anteriorly notched. Median ocular tubercle weak, smooth, with a pair of large median eyes, tubercle situated anteriorly in a ratio 1:1.5. Lateral ocular tubercles smooth, weak, located on the edge of the lateral margin of the carapace provided with three eyes.

Table 1: Morphometrics of female *Liocheles nigripes* recorded with a digital vernier calliper (±0.01 mm)

Character	*Liocheles nigripes* (BNHS-Sc-20) (in mm)
Carapace length	4.58
Carapace anterior width	3.95
Carapace posterior width	5.22
Mesosoma	9.18
Metasoma (broken)	9.15
Vesicle width	1.05
Vesicle length	1.82
Aculeus length	0.53
Femur length	3.75
Femur width	1.68
Patella length	3.77
Patella width	2.21
Chela length	7.65
Movable finger	3.41

Mesosoma: Tergites smooth, punctate with an elevated medial region. Sternites smooth with slit-like stigmatas. Pectines weak, almost one and a half times as long as wide. Middle lamellae inconspicuously divided into three digits. Fulcra distinct. Lamellae and fulcra with minute red setae. Pectinal teeth 6/6 in number. Genital operculum with a distinct median suture. Sternum pentagonal.

Metasoma: Weak, setose and punctate. Segment I smooth with weak carinae; Segments II-IV almost entirely smooth except on the inferior carina on segment II; Segment V smooth except on inferior and inferior lateral carinae. Anal rim crenulated medially and lobate laterally. Vesicle globular, densely setose with a short weakly curved aculeus.

Chelicerae: Basal segment smooth, ventrally covered with fine hairs. Dentition as per characterized in the family and genus.

Pedipalps: Dorsoventrally flat, punctate and granular. Carinae rudimentary. Dentition on fingers on chela in two rows. Trichobothrial pattern Type C on femur, patella and chela (see Fig 1384-1389 in Tikader and Bastawade 1983). Trichobothria Et 2-5 on external surface of chela placed linearly.

Habitat: Kanger Valley National Park (KVNP) is located in Bastar district, south Chhattisgarh. It lies between 81° 51' 30"-82° 10' 00" N and 18° 45' 00"-18° 56' 30" E, covering a total area of 200 sq. km. The mean annual rainfall received is *c*. 1,516 mm of which almost 80% is received from July to August.

Botanically, the region is situated in the transition zone between the southern limits of Sal forests and northern limits of Teak forests. Thus, both plantations overlap in the extent of the Park forming a dense forest classified as Moist

Table 2: Table summarizing the forest types and floristic characters of known localities of *L. nigripes*

Locality	Forest type	Characteristic flora
Gonda	*Aegle* forest (Type 5 E6)	*Aegle marmelos*, *Diospyros tomentosa* and *Ziziphus glaberrima*
Almora	Moist Temperate Deciduous forest	*Aesculus indica* and *Acer* sp.
Udaipur	Northern Tropical Throne forest	*Acacia* and *Euphorbia* sp.

c. 1,516 mm of which almost 80% is received from July to August.

Botanically, the region is situated in the transition zone between the southern limits of Sal forests and northern limits of Teak forests. Thus, both plantations overlap in the extent of the Park forming a dense forest classified as Moist Peninsular Sal Forest, which is characterised by *Shorea robusta*, *Terminalia tomentosa* and *Madhuca indica* (Champion and Seth 2005). Large trees coupled with bamboo (*Dendrocalamus strictus*) thickets make it one of the densest forests of central India. Biogeographically, it falls under zone '3C-Deccan peninsula' and forms boundary with the Eastern Ghats zone.

Discussion

All historic records of *L. nigripes* from India have been north of 22° N, while the present report from KVNP is south of 19° 15' N. This is thus the southernmost report of *L. nigripes* from India. This record represents the first record of *L. nigripes* from within the political boundary of Chhattisgarh and extends its previously known range by *c.* 600 airline kilometres south-east from the closest locality Satna, Madhya Pradesh (Caius 1942). During the surveys in KVNP *Buthoscorpio politus* and *Lychas* species were found sympatric to *L. nigripes*. These findings merely reflect how little is known of the scorpion fauna of this area, and more generally many parts of India. Thus, the possibility of *L. nigripes* occurring in other similar contiguous biotypes cannot be ignored.

Interestingly, in India, the species seems to occur in extremely varied forest types over a wide altitudinal range from 120 m above msl (Gonda) – 1,642 m above msl (Almora). The forest types existing at various localities of *L. nigripes* have been summarized (as per Champion and Seth 2005).

Table 2 indicates the presence of *Liocheles nigripes* across a range of biomes from dry thorn, temperate deciduous to moist peninsular Sal forest. These are highly contrasting biotypes, suggesting that the species is either highly generalist in its habits or the presence of a potential species complex comprising of multiple undescribed species. Future collections with precise identification and accurate locality are vital to revalidate current knowledge of this poorly studied species.

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10. *GLOBBA ORIXENSIS* ROXB. (ZINGIBERACEAE) – A NEW RECORD FOR THE FLORA OF ASSAM, INDIA

Lalawmkima Darlong[1,2] and Debjyoti Bhattacharyya[1,3]

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The genus *Globba* L. (Zingiberaceae) is represented by about 100 species in the world (Williams *et al.* 2004), with the main centre of distribution in tropical Asia. In India, the genus is represented by 17 species (Karthikeyan *et al.* 1989) with 4 species in Assam (Chowdhury 2005). During field survey in different regions of Barak Valley, we collected some specimens from Cachar district of Assam. On critical examination and herbarium (CAL) consultation, the specimens were identified as *Globba orixensis* Roxb. A perusal of relevant literature (Kanjilal *et al.* 1934-40; Rao and Verma 1972; Jain and Prakash 1995) revealed that the species was not hitherto known from Assam. So, it is reported as a new record for the flora of Assam.

Globba orixensis Roxb. in *Asiat. Res.* 11: 358. 1810 & *Pl. Cor.* t. 229. 1815; Baker in Hook. f., *Fl. Brit. India* 6: 201. 1890. (Fig. 1).

Erect, faintly aromatic, perennial herbs; rhizome creeping with fleshy roots. Leafy shoot 30-35 cm high, green, swollen at base; sheaths 10-15 cm broad at base, puberulous outside and glabrous inside. Leaves simple, alternate, broadly lanceolate, 5-7 × 1.5-2 cm, sub-sessile, cuneate at base, caudate at apex, entire at margin, glabrous on both surfaces; midrib prominent with 8-15 parallel nerves; ligules 1-3 mm long, green with ciliate margin. Panicles terminal, *c.* 6.5 cm long; bracts lanceolate, 5-7 × 2-3 mm, acute at apex, deciduous. Flowers 4-5 cm long, orange-yellow. Calyx infundibuliform, 0.5-1 × 0.2-0.3 cm, glabrous, yellow; teeth minute, tridendate. Corolla tube *c.* 1.5 cm long, slender, 3-lobed; lobes subequal, 6-8 × *c.* 3 mm, orange-yellow. Staminodes 2, subequal, *c.* 5 × 2 mm, petaloid, orange-yellow with deflexed lip; labellum narrow, shallowly bifid, glabrous, orange-yellow with reddish brown spots at throat. Filament of the fertile stamen *c.* 2.4 cm long, yellow, glabrous, arched; anther 2-celled, oblong, *c.* 2 mm long, nearly acute at apex, pale-yellow, dorsifixed. Ovary unilocular; ovules many on parietal placenta; style linear, 2-2.5 cm long, glabrous, white; stigma cupular with ciliate mouth; nectar glands linear, 4-5 mm long. Infructescence 6-6.5 cm long, dark maroon at base with persistent calyx. Capsule globose, *c.* 1 cm in diameter, warted; seeds numerous, brownish red, arillate, faintly ciliate at margin; aril black.

Fl. & Fr.: July-August.

Habitat: The species is commonly found in damp, shady and moist places of the forest areas of hillocks.

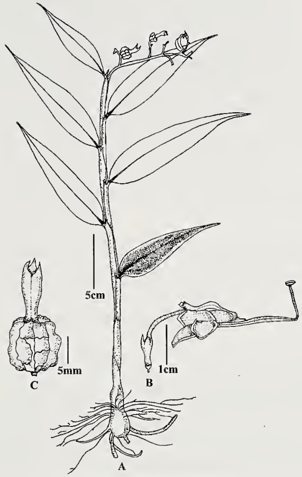

Fig. 1: *Globba orixensis* Roxb.
a. Habit; b. Flower; c. Fruit.

Occurrence: Not common; localized in small patches.

Distribution: India: Andhra Pradesh, Madhya Pradesh, Orissa, Jharkhand, West Bengal, Sikkim, Assam (present study), Meghalaya, Mizoram, Tripura; Myanmar; Malaysia; Thailand.

Specimens Examined: Assam, Barak Valley, Cachar district, Kumbhirgram, 21.vii.2009, Coll.: D. Bhattacharyya 2501, Fl. & Fr.; Dargakona, Assam University Silchar Campus, behind Life Science and Bioinformatics Department, along the trek path to eco-forest, 24° 41' 13.2" N & 92° 45' 7.9" E, 13.vii.2010, Coll.: L. Darlong & D. Bhattacharyya 10063, Fl. (Herbarium of Department of Life Science & Bioinformatics, Assam University, Silchar).

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ERRATA

Volume 108(1) January-April 2011:

i. page 29, Fig. 3

For: "Fig. 3: Fruit colour spectra of bird (n=380) and mammal (n=46) fleshy-fruits"

Read: "Fig. 3: Fruit colour spectra of bird (n=38) and mammal (n=46) fleshy-fruits"

ii. page 44, Table 2

For: "SI No. 17. Scientific name: *Garra hughi* (Hughi)"

Read: "SI No. 17. Scientific name: *Garra hughi* (Silas)"

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Cover Photograph: Dhole *Cuon alpinus* by Vandan Jhaveri

Editorial

State Species: Need to go beyond symbolism

During a meeting of the Indian Board for Wildlife, now called National Board for Wildlife, in the 1960s, a suggestion was made to identify a national animal and a national bird. The Government of India notified Lion as the National Animal and Peacock (not Peafowl, to be gender neutral) as the National Bird. In 1972, the Lion was dethroned and the Tiger became the National Animal, as it is found in many parts of India, unlike the Lion that is now confined to Gujarat (at that time, the Tiger was reported even from north Gujarat, where it became extinct in the late 1970s).

The Indian Board for Wildlife also suggested that every state should identify its state animal, bird, tree and flower. This was mainly to highlight the importance of a particular species for the state, and also to take conservation initiatives for those species. Now, most of the states of India have a state animal, bird, tree and flower (Sinha 2001). For example in Rajasthan, Chinkara *Gazella bennettii* is the State Animal, Great Indian Bustard *Ardeotis nigriceps* is the State Bird, Khejri *Prosopis cineraria* is the State Tree and Rohida *Tecomella undulata* is the State Flower. In Uttar Pradesh, Swamp Deer *Rucervus duvauceli duvauceli* is the State Animal and Sarus Crane *Grus antigone* is the State Bird. In Assam, One-horned Rhinoceros is the State Animal and White-winged Wood-Duck *Asarcornis scutulata* is the State Bird. The idea behind declaring state animal/bird/tree was that these states would take special care of 'their' species. For example, more than 50% of Indian population of Sarus Crane is found in Uttar Pradesh, so it is appropriate to have this species as the State Bird. Similarly, almost 80% of India's Rhinoceros population is found in Assam, so Assam is the real custodian of this magnificent animal. While some states have taken this issue seriously, the majority of them have clearly forgotten their duty. In some states there is no attempt whatsoever to protect the species – symbolic declaration of state bird, state animal and state tree was considered enough by them. Even in states that have taken some interest, it is only large, glamorous animals that are given attention, whereas 'plebeian' species are not considered worthy of attention. For example, in Assam, all attention is focused on Rhino protection, which admittedly is a noble intent. 'Rhino Mission 20:20' is being implemented, whereby the Assam Government intends that by the year 2020 the One-horned Rhinoceros population in the state will increase to 3,500 from its present population of 2200. Attempts are being made to eliminate or minimize Rhino poaching, and to reintroduce this animal in areas where it was eliminated, e.g., in Manas National Park. All these measures are praiseworthy, but the flipside is that practically no attempt is being made to conserve the State Bird – White-winged Wood-Duck. Whatever small isolated numbers are surviving are only by chance, not design. There is no serious attempt to increase its number and save its small forest wetland habitats. Even the conservation breeding attempts by a tea estate in the 1970s could not take off due to lack of expertise. Up to the 1990s, it was recorded in nearly 36 sites in Assam, and there were dubious records at 11 more sites (Choudhury 2000). Now it has disappeared from 12 major sites (Rahmani and Choudhury 2012).

Similarly, Kashmir Red Deer or Hangul *Cervus elaphus hanglu* is the State Animal of Jammu & Kashmir, whereas the Black-necked Crane *Grus nigricollis* is the State Bird of Jammu & Kashmir. The Hangul has been endemic to Kashmir mountains, and the Gamgul Siabehi Sanctuary in Chamba district, Himachal Pradesh, on the border with Jammu & Kashmir, was the only area outside J & K where Hangul was reported in the past. However, there has been no recent record of Hangul from Himachal Pradesh (Ahmad 2006; Ahmad *et al.* 2009). Even in J & K it is fighting for survival, and only one viable population of 140 to 170 animals is found in Dachigam National Park (Ahmad *et al.* 2009). As a national park, Dachigam should have the highest degree of protection with no human presence other than the wildlife authorities that have a stake in the Park. However, Dachigam National Park is quite different from other protected areas in the country. It has a large sheep breeding farm right in the middle of the Park which, despite many recommendations during the last 30 years, has not been removed. The state government does not follow its own recommendations to protect the State Animal! Upper Dachigam, where the poor animal goes during summer is over run by nomadic graziers – removing them is a political issue. The fact is that graziers have many other areas to graze their livestock but Hangul, the pride of the State, does not have such a choice. The productivity of adults and survival of young ones in deer depend on the nutritive quality of their food (Clutton-Brock and Albon 1989), but we do not even know whether Hangul has declined to such a low number due to lack of the right nutrients. Recent studies carried out on Hangul (Ahmad *et al.* 2009) revealed that livestock grazing and biotic interference seemed to have some significantly positive impacts on the movement patterns of Hangul in Dachigam NP (Ahmad 2006; Ahmad *et al.* 2009). Similar patterns have been reported in the displacement and dispersion of Elk and Red Deer away from the areas used by livestock in summer (Clutton-Brock *et al.* 1982; Clutton-Brock and Albon 1989) and Sambar (Sathyakumar 1994; Khan 1995). After many delays, the State Government has established a Hangul Conservation Breeding Centre at Shikargah Tral, but at present there is no animal in the Centre.

Uttar Pradesh Government has taken many measures to protect Sarus Crane. Sarus Protection Society, with a corpus of ten million Indian rupees has been established. Regular surveys are being done and there is another scheme to revive small wetlands, not only for Sarus but to improve ground and surface water resources for farmers. Signboards have been put up in different areas to publicize that Sarus is the State Bird. Good measures have been taken to protect Swamp Deer, the State Animal of Uttar Pradesh, with a result that its population has increased in Kishanpur WLS and Dudhwa NP. A small population in Katerniaghat WLS is also showing signs of revival, but much more has to be done to increase its population by reintroducing some individuals from Kishanpur to increase the genetic diversity. Similarly, attempts should be made to increase the population of Swamp Deer in Pilibhit Reserve Forests.

Rajasthan has Great Indian Bustard (GIB) as the State Bird but no special measures are taken to protect this rarest bustard of the world. Perhaps less than 200 survive in the whole state. It is extinct from Sorsan Bustard Area in Baran district, which was specially declared a protected area for this species, and less than 10 are left in Sonkhaliya area in Ajmer district, which was specially declared as "Close Area for Shooting" in the 1980s. At that time nearly 60-80 bustards were present in Sonkhaliya area (Rahmani and Manakadan 1988). Now only scattered populations are found in some remote parts of the Thar Desert, and even these birds are not safe from poachers and severe over-grazing. The fences of core grassland enclosures in the Desert National Park have not been repaired for the last 30 years due to lack of funds! These enclosures are the only areas where the GIB can breed in safety. Despite the fact that GIB will not be difficult to breed, no attempt is being made to start a conservation breeding programme. Lack of funds is often cited. Imagine, a state government does not have a few million rupees to protect one of India's critically endangered species, which also happens to be its State Bird.

Greater Flamingo *Phoenicopterus ruber* is the State Bird and Asiatic Lion *Panthera leo persica* the State Animal of Gujarat. While the Gujarat government is keen to close an existing road inside Gir Wildlife Sanctuary to minimize disturbance to the 'pride of Gujarat', as most Gujaratis feel, the same Government is very keen to build a new 4-lane road merely 4-6 km from the only known flamingo breeding site, not only in Gujarat but the whole of India. There are many such examples of state totally neglecting their own state animals or birds. Another example: Mrs Hume's Pheasant *Syrmaticus humiae* is the State Bird of Manipur and Mizoram, but I do not know of any scheme by these states to protect this Near Threatened species, except in a few protected areas. In Manipur, it is found in Shiroi Ridge forest, but the habitat is under severe threat of shifting cultivation (Choudhury 2002, 2009; Rahmani 2012).

Blackbuck *Antilope cervicapra* is the State Animal of three states, Andhra Pradesh, Haryana and Punjab, and Asiatic Elephant *Elaphus maximus* of four states, Jharkhand, Karnataka, Kerala and Orissa. It must be acknowledged that declaring these animals as state animals has benefited them by minimizing poaching, in the case of Blackbuck so much so that in some areas (e.g., Abohar in Punjab), it has become a big problem for crops. Considering its importance as a farm animal and an important genetic resource, Arunachal Pradesh has declared the Mithun *Bos gaurus frontalis*, a hybrid of Gaur and domestic cattle, as its State Animal. The State Bird is Great Pied Hornbill *Buceros bicornis*, which is extensively hunted by tribals for the use of feathers and casque in their traditional headgear and for meat. Mithun is also the State Animal of Nagaland.

Interestingly, some states have declared supposedly common species as their state bird. The White-breasted Kingfisher *Halcyon smyrnensis* is the State Bird of West Bengal, Koel *Eudynamys scolopaceus* of Jharkhand, Asian Paradise-Flycatcher *Terpsiphone paradisi* of Madhya Pradesh, and Green Imperial-Pigeon *Ducula aenea* of Maharashtra. The last named species is also the State Bird of Tripura. Culturally important species have been listed in many states. For example, Himalayan Monal *Lophophorus impejanus* is the State Bird of two neighbouring states, Himachal Pradesh and Uttarakhand, where it is considered auspicious by some communities. Northern Goshawk *Accipiter gentilis*, associated with revered Sikh gurus, is the State Bird of Punjab. Despite the Peacock being a national bird, Orissa Government has adopted it as the State Bird also. Such is the cultural and spiritual importance of this iconic bird. Ashoka *Saraca indica*, is a tree revered by Hindus and Buddhists. Maya, mother of the Buddha, is said to have retired to an Ashoka grove when she became aware that she had conceived a child. It is mentioned in the Ramayana that the chaste Sita sat in an Ashoka grove during her long period of captivity in Lanka.

Some states have considered economically important trees such Deodar *Cedrus deodara*, Iron Wood *Mesua ferrea* and Hollong *Dipterocarpus retusus* as their State Tree. Interestingly, most of the state trees or state flowers have popular local names, indicating the cultural, economic, ecological and spiritual importance of these species to the local people/state.

The initial idea behind identifying state animal, bird, tree and flower was to give greater conservation importance to these species – a sort of conservation symbol, or flagship species as we say in scientific jargon. Although some states have taken this as a serious issue, most states have not gone beyond symbolism. Is symbolism enough for conservation? The answer is no. This message should go to all states that they should be proud of 'their' animal, bird, tree and flower, and take effective measures to see that the state retains its pride.

Asad R. Rahmani

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(With inputs of Dr. Anwaruddin Choudhury and Dr. Khursheed Ahmad)

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OCCUPANCY AND ABUNDANCE OF DHOLE (*CUON ALPINUS*) IN PENCH LANDSCAPE OF CENTRAL INDIA

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Occupancy and abundance of dhole was studied in the Pench landscape of Central India between 2006 and 2010. Royle-Nichols heterogeneity model was used for abundance estimation of dhole. The 4,300 sq. km area of the Landscape was divided into 10 km x 10 km grids (n=43), considering each grid size is larger than the home range size of an individual dhole.

Different forest routes on each grid were surveyed to collect indirect evidences (spoor, fresh scats, etc.) of dhole, and each search covered 5 km distance (total effort 3,720 km) during 2006. The average dhole pack size was 13.9 ±1.4 (Standard Error or SE). The estimated individual density of dhole in the Pench landscape was 3.3 ±1.2 (SE)/100 sq. km. Naïve or site occupancy of dhole was estimated using indirect evidences from the Intensive Study Area or ISA (410 sq. km), i.e., in Pench National Park (PNP) and Pench Wildlife Sanctuary (PWS) of Pench Tiger Reserve, Madhya Pradesh, between February and June 2006, 2007, 2009 and 2010. Sampling occasions (n=3) were same for all four years and total effort varied between 725 km and 750 km. The estimated naïve or site occupancy of dhole in ISA was 0.81 ±0.07 (SE) in 2006 followed by 0.96 ±0.15 in 2007, 0.52 ±0.08 in 2009 and 0.82 ±0.14 in 2010.

Our study revealed that occupancy of dhole is high inside the Pench Protected Area (i.e., PNP and PWS), but low and patchy outside. As dhole population is observed fragmented, linkage between the different Protected Areas in this landscape is crucial for its long term survival.

Key words: *Cuon alpinus*, Pench landscape, abundance, occupancy, central India

INTRODUCTION

With the decline of most large carnivore population worldwide (Nowell and Jackson 1996) there is always an urgent need for practical and accurate methods of estimating population numbers and monitoring trends (Caughley and Sinclair 1994). Estimates of abundance are extremely valuable for species conservation, yet determining the abundance of elusive and wide-ranging carnivores is difficult, but possible, especially for those that can be identified by individual marking, like Tiger *Panthera tigris* (Karanth 1995; Sharma *et al.* 2010; Jhala *et al.* 2011), Leopard *Panthera pardus* (Mondol 2006; Edgaonkar 2008; Harihar *et al.* 2009; Ramesh 2010), Jaguar *Panthera onca* (Soisalo and Cavalcanti 2006) and Cheetah *Acinonyx jubatus* (Marnewick *et al.* 2008). Kelly *et al.* (2008) assessed reliability of Puma *Puma concolor* identification by photo-trapping using double-blind observer identifications. They also reported that obvious and subtle markings (scar, cut marks and wounds) of the species can be compared from camera trap photographs if the photo quality is good. Carbone *et al.* (2001) used photographic rates to estimate densities of cryptic mammals, which require large sample size. Rowcliffe *et al.* (2008) also estimated animal density, without the need for individual recognition, from camera trapping rates by modelling the underlying detection process. Radio telemetry study was also used to estimate population of some large-bodied canids like Dhole *Cuon alpinus* (Acharya *et al.* 2007), Wolf *Canis lupus* (Mech 1977), Coyote *Canis latrans* (Andelt 1985). Radio-telemetry is constrained by the small number of animals that can be tagged simultaneously, the uncertainties about how many individuals are tagged, and the high costs and efforts involved (Karanth 1995). Kohn *et al.* (1999) estimated coyote population by genotyping faeces. Though this method may be more reliable for population estimation, because of its non-invasiveness (Miththapala 1996), the major drawback is high cost and need of skilled technicians and advanced laboratories (Kohn *et al.* 1999).

The only information on dhole abundance comes from a few protected areas in southern and central India (Johnsingh 1983, Karanth 1993, Venkatraman *et al.* 1995, Acharya *et al.* 2007). These estimates have not been obtained through systematic sample based survey methods, but on estimates of number of packs within the protected areas (derived using known home range areas and knowledge of mean pack sizes) (Durbin *et al.* 2004). Ramesh (2010) estimated population of Dhole using vehicle transect method.

As dholes are the least studied social carnivores in the Asian jungles (Acharya *et al.* 2007), the present study was carried out in the Pench landscape of central India, between June 2006 and June 2010, to estimate occupancy and abundance of dholes using reliable scientific methods.

MATERIAL AND METHODS

Study area

The study area, Pench landscape (4,300 sq. km) is one of the important conservation units for carnivores and its prey in the central Indian landscape (Jhala *et al.* 2010) (Fig. 1). According to Champion and Seth (1968) classification, the study area falls under tropical dry deciduous forest and tropical moist deciduous forest. It includes Pench Tiger Reserve, South Seoni Forest Division, South Balaghat Forest Division, East Chindwara Forest Division and South Chindwara Forest Division. This Landscape lies in the southern lower reaches of Satpura Hill ranges. According to the biogeographic classification of Rodgers and Panwar (1988), it lies in the Zone – 6E Deccan Peninsula Central Highland. The terrain is gently undulating and criss-crossed by small streams and nullahs, most of these are seasonal. The study area experiences markedly seasonal climate with a distinct summer (March-June), monsoon (July-September) and winter (October-February) and receives a mean annual rainfall of *c.* 1,400 mm. The temperature ranged from 2 °C in winter to 49.5 °C in summer. Pench Tiger Reserve (PTR), which includes Pench National Park (PNP) and Pench Wildlife Sanctuary (PWS), along with Kanha Tiger Reserve constitutes one of the 11 level-I Tiger Conservation Units (TCU) in India classified by Wickramanayake *et al.* (1998). The PNP and PWS were considered as the intensive study area (410 sq. km) for the present study. Apart from dhole the other carnivore species found in this landscape are tiger, leopard, wolf, jackal (*Canis aureus*), Striped Hyena (*Hyaena hyaena*), Indian fox (*Vulpes bengalensis*) and Jungle cat (*Felis chaus*). The wild ungulates found here are Chital (*Axis axis*), Sambar (*Rusa unicolor*), Nilgai (*Boselaphus tragocamelus*), Gaur (*Bos frontalis*), Barking Deer (*Muntiacus muntjak*), Chousingha (*Tetracerus quadricornis*), Wild Pig (*Sus scrofa*), Blackbuck (*Antilope cervicapra*) and Chinkara (*Gazella bennettii*) (Sankar *et al.* 2001; Dungariyal 2008; Jhala *et al.* 2010). The Common Langur (*Semnopithecus entellus*) and Rhesus Macaque (*Macaca mulatta*) represent the primate fauna of the area. The Indian Crested Porcupine *Hystrix indica*, Black-naped Hare (*Lepus nigricollis*), Indian Flying Fox (*Pteropus giganteus*), Red Giant Flying Squirrel (*Petaurista petaurista*), Three-striped Squirrel (*Funambulus palmarum*) and Indian Pangolin (*Manis crassicaudata*) also occur in this area. There are over 51,648 inhabitants in 107 villages and 60,000 livestock present around the notified buffer zone of PTR (Dungariyal 2008). The mean human population density is 112 ±9 (Standard Errror or SE) / sq. km and Gond tribes are the main inhabitants of this landscape (Qureshi *et al.* 2006; Jhala *et al.* 2010).

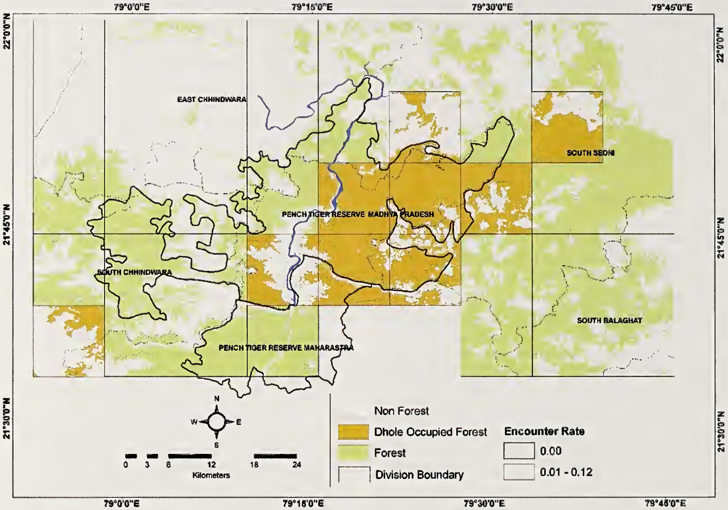
Methods

We used Royle-Nichols (Royle and Nichols 2003) heterogeneity model for abundance estimation of dhole. The key assumptions of the Royle-Nichols model are (1) the number of animals at a particular site follow a Poisson probability distribution for which lambda indicates the mean abundance across all sites, and (2) the probability of detecting animals at each site is related to the species specific capture probability 'r' and the site abundance (Ni).

Royle-Nichols heterogeneity model was used for larger data set (4,300 sq. km) for 2006 from 'Monitoring tiger, co-predator, prey and their habitat'- research project (Jhala *et al.* 2008). The parameter derived from larger study area was used to infer abundance of dhole in the intensive study area (410 sq. km). This larger study area was further sub-divided into 10 km x 10 km grids (n=43) (Fig. 1) and our assumption was that the grid size should be more than the home range size of a dhole pack. The average home range of dhole pack was 63 sq. km as reported by Acharya *et al.* (2007) in the same study area. Forest beats were considered as the lowest sampling unit for sign survey (Jhala *et al.* 2008) and three separate routes of each forest beat were walked early in the morning to record the signs and tracks of dhole. Each search covered 5 km having the best potential for dhole presence. Data collection was done covering 3,720 km. The site (naïve) occupancy (Mackenzie *et al.* 2002) of dhole population was estimated from beat wise (n=44) sign survey in the ISA in 2006, 2007, 2009 and 2010. Sampling occasions (n=3) were same for all the four years and total effort varied between 725 km and 750 km. The program PRESENCE ver. 3 was used for occupancy and abundance estimation (Jhala *et al.* 2010). T-test (Zar 1984) was used to evaluate temporal changes in occupancy.

RESULTS

The estimated occupancy of dhole in the overall landscape was 0.21 ±0.06 (SE). Detection probability was 0.74 ±0.09 (SE) and average dhole pack size was 13.9 ±1.4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N
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0 3 6 12 18 24
Kilometers
Non Forest
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Forest
Division Boundary
Encounter Rate
0.00
0.01 - 0.12

Fig. 1: Map showing grid wise (n=43) occupancy and encounter rate (signs/100 sq. km) of Dhole in Pench landscape (4,300 sq. km)

(SE). The estimated average abundance of dhole in the landscape was 0.24 ±0.08 (SE)/100 sq. km. The estimated individual density of dhole in the overall landscape (multiplying average pack size of dhole with average abundance) was 3.3 ±1.2 (SE)/100 sq. km for 2006 (Table 1).

The estimated naïve or site occupancy of dhole in the ISA, i.e., Pench National Park and Sanctuary for 2006 was 0.81 ±0.07 (SE) followed by 0.96 ±0.15 (SE) in 2007, 0.52 ±0.08 in 2009 and 0.82 ±0.14 in 2010, whereas detection probabilities were 0.65 ±0.05 (SE) in 2006, 0.35 ±0.06 (SE) in 2007, 0.56 ±0.07 (SE) in 2009 and 0.37 ±0.07 (SE) in 2010.

Table 1: Summary of dhole abundance estimates (Individuals/100 sq. km) in Pench landscape, central India

Parameters	Value
Sampling area (sq. km)	4,300
Detection probability or r	0.74 ±0.09
Average abundance ±SE	0.24 ±0.08
Occupancy	0.21 ±0.06
Average pack size ±SE	13.9 ±1.4
Number of individual ±SE (/100 sq. km)	3.33 ±1.2

*SE= Standard Error

The estimated site occupancy did not differ significantly (p=0.16) between 2006 and 2007, whereas it differed (p=0.009) between 2007 and 2009, 2009 and 2010 (p=0.03).

DISCUSSION

Estimating populations of species that cannot be identified individually is difficult. Estimating abundance from Royle-Nichols heterogeneity models was found to be more appropriate for our study as dhole cannot be identified by any unique marking pattern. The estimated dhole density, i.e., 3.3 ±1.2 /100 sq. km in the present study was found lower than Bandipur (Johnsingh 1983), Mudumalai (Ramesh 2010), PTR (Acharya *et al.* 2007), Mudumalai (Venkatraman *et al.* 1995) and Nagarhole (Karanth 1993) (Table 2). According to Acharya *et al.* 2007, within peninsular India, dholes are encountered specifically in dense forests and thick scrub

Table 2: Estimated Dhole densities (individuals/100 sq. km) from different Protected Areas in the Indian subcontinent

Locations (Authors and year)	Study Area (sq. km)	Density/ 100 sq. km	Pack Size Range	Method
Mudumalai (Ramesh 2010)	107	43.0 ±21.0	1-28	Vehicle Transect
Mudumalai (Venkatraman *et al.* 1995)	321	31.2 ±-	4-25	Direct observation
Bandipur (Johnsingh 1982)	20	35-90	7-18	Direct observation
Nagarhole (Karanth 1993)	100	14.0 ±-	3-10	Direct observation
Pench TR (Acharya *et al.* 2007)	410	29.0 ±2.0	1-14	Radio Telemetry and direct observation
Nilgiri Plateau (Cohen *et al.* 1978)			1-5	Direct observation
Present study	4,300	3.3 ±1.2	1-29	Estimated abundance using Royle and Nichols heterogeneity model

jungles (Krishnan 1972; Davidar 1974), unlike the wild dogs of the African savannah. In most of the sites (Table 2), studies were conducted in well-managed habitat with high prey density and smaller area (20 sq. km to 410 sq. km), whereas our study area was large and covered gradient of forest and variable prey density (low to high). The earlier study on population estimation of dhole (Acharya *et al.* 2007) was restricted inside the PNP and PWS. The estimated high site occupancy (>80%) of dholes in the intensive study area (PNP and PWS) by the present study is attributed to high abundance of wild prey and well-managed habitat (Biswas and Sankar 2002, Jhala *et al.* 2010). Our findings also provided insights on conservation of large carnivores outside the PTR, as comparatively high dhole signs were encountered (> 0.12/100 sq. km) inside the PTR, whereas very low sign intensity (<0.0001/100 sq. km) was encountered outside the PTR (Fig. 1).

Conservation implication

The dhole has been facing a variety of threats from humans. Encroachments by humans into its forested habitat for agriculture, stealing of kills, cattle grazing, fodder, fuel-wood, and non-timber forest products collection have pushed the dhole to high degree of isolation and even local extinction (Johnsingh 1985, Acharya *et al.* 2007). More so, increasing cases of poisoning, poaching and resultant prey depletion may have contributed greatly to hasten the dholes' decline (Fox 1984), making it go the way of the African wild dog (*Lycaon pictus*). Durbin *et al.* (2004) reported diseases are significant threat in South Asia, particularly those transmitted from feral or domestic dogs, e.g., canine distemper and mange. Acharya *et al.* (2007) reported the greatest threat to dholes is from the domestic and feral dogs all around the Pench Tiger Reserve, Madhya Pradesh. Both Qureshi *et al.* (2006) and Jhala *et al.* (2010) reported that Pench landcape has forest connectivity with Kanha landscape and Satpura landscape, and forms an important conservation unit for large carnivores in central Indian landscape. The reported occupancy of dhole in overall Central Indian landscape was 85,962 sq. km in 2006 (Jhala *et al.* 2008) and 71,817 sq. km in 2010 (Jhala *et al.* 2010). Though Wildlife (Protection) Act of 1972 has helped to check the drastic decline of the dhole in many reserves within India (Ginsberg and Macdonald 1990), our study revealed that occupancy of dhole was high inside the Pench Protected Area (i.e., PNP and PWS), but low and patchy outside. As dhole population is observed fragmented, linkage between different protected areas in this landscape is crucial for long term survival of the dhole.

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IDENTIFICATION OF BIOMES AND THEIR INDICATOR TAXA FOR CONSERVATION PLANNING: A CASE STUDY FROM CENTRAL INDIAN BIRDS

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Identification of biomes and their indicator taxa is a key component of spatial conservation plans, including rationalization of Protected Area (PA) network. Here, we seek to demonstrate the potential of Indicator Species Analysis (ISA) in identifying landscape-level biomes and their indicator taxa using birds of Central Indian Highlands in Madhya Pradesh. The study area was gridded into 284 contiguous quarter-degree cells, and data on distribution of 190 species of breeding land birds were collected for all the quadrats using a spatially hierarchical sampling scheme. We used a combination of cluster analysis and ISA to extract ecologically and statistically significant number of clusters that corresponded to distinct avian assemblages representing different biomes. In total, seven biome-restricted avian assemblages were identified along three gradients, namely vegetation, elevation, and rainfall. Among them, high-elevation moist deciduous forest harboured the largest number of biome-specialists with high indicator values. We then assessed the adequacy of the existing PA network with respect to coverage of the four forest biomes. Barring the low-rainfall teak forest, all the other biomes had more than 10% area under PA network. We discuss the conservation implications of this bias for central Indian avifauna and need for evolving multi-species criteria for prioritizing conservation areas.

Keywords: birds, tropical forests, Indicator Species Analysis, Protected Area network, biomes, Central Indian Highlands

INTRODUCTION

How to conserve biological diversity in an increasingly fragmented landscape of natural areas has always been a central challenge faced by conservationists and policy makers (Burbidge and Wallace 1995). Creation of a network of Protected Areas (PAs) that are relatively free from external interference remains the most efficient strategy (Trombulak *et al.* 2004; Locke and Dearden 2005), though alternative paradigms, such as participatory management are also being increasingly experimented, with mixed results (Mehta and Kellert 1998; Attwell and Cotterill 2000; Berkes 2004). But PA network cannot be infinitely large in size in a landscape like the Central Indian Highlands where a sizeable number of native people directly depend on forestry resources for sustenance, and demand for land is growing fast to meet their economic and livelihood needs. Therefore, conservationists prescribe that an optimal portion of wilderness area be brought under PA network that seeks to protect maximum biodiversity at a minimal socioeconomic cost (Trombulak *et al.* 2004). How much area would make up this optimum has been a matter of much debate and discussion. A broad consensus is that all the major biomes in a landscape should be adequately represented in a PA network, with minimum recommended area for each biome ranging from 10% (e.g., IUCN 1993) to 15% (e.g., European Commission 1992).

This biome-based approach is the key to developing an inclusive and representative PA network, as occurrence of surrogate taxa like an umbrella species or a flagship species often prompts declaration of a site as a Protected Area. Though surrogate taxa have an admirable role in garnering political and public support for setting aside exclusive areas for conservation (Walpole and Leader-Williams 2002), this approach is known to overlook other important species leaving several gaps in the PA network (see Caro and O'Doherty 1999; Roberge and Angelstam 2004). Therefore, a multi-species analysis is strongly recommended in identifying faunal biomes and in ranking sites for their conservation value (Reyers *et al.* 2002; Roberge and Angelstam 2004; Rodrigues *et al.* 2004; McCarthy *et al.* 2006).

The concept of biome has also been increasingly used as a biogeographical tool in conservation plans other than PA network analysis, either as a suite of landscape species (Coppolillo *et al.* 2004) or as a typology of eco-climatic communities (e.g., biomes as defined by BirdLife International; Islam and Rahmani 2004). In particular, the latter is one of the key criteria (A3) for identifying and developing a global network of Important Bird Areas.

Identification of ecologically significant biomes in a landscape is often a computationally challenging task that involves extensive use of multivariate statistical techniques. The assemblages of species characteristic of particular biomes are normally delineated by classifying sites into distinct clusters based on their similarity in species composition. Data on presence/absence (or relative abundance) of species in each of the sampling units (usually spatially contiguous grids at various scales) are analyzed using a classification technique like cluster analysis (Crowe and Crowe 1982; Muriuki *et al.* 1997) or an ordination method (Reyers *et al.* 2002). A thorny issue in such multivariate approach is the uncertainty over the optimal number of clusters (biomes) to be extracted for further investigations. In an attempt to overcome this problem, Dufrêne and Legendre (1997) developed a non-parametric Indicator Species Analysis (ISA) in which indicator values of all the species for each biome were computed along with their associated *P*-values at different cluster levels (through randomizations), and the most significant number of clusters would be the one at which the mean pooled *P*-value was observed to be the lowest. The indicator value of a species is expressed as a non-parametric function of site specificity and site fidelity. ISA has also been successfully adopted in several recent studies to identify unique sets of ecological communities and assemblages and their indicator taxa (Orrock *et al.* 2000; Heino *et al.* 2003; Venier and Pearce 2005; Shahabuddin and Kumar 2006).

Though ISA is conceptually simple and straightforward to use, its potential as a statistical tool in conservation science remains largely untested in India (barring Shahabuddin and Kumar 2006), in sharp contrast to its popularity elsewhere. Here, we seek to demonstrate its application in identifying landscape-level biomes and their indicator species using information on distribution of breeding land birds in tropical deciduous forests of central India. We then assess the adequacy of the existing PA network in the region vis-à-vis extent of coverage of these biomes.

METHODS

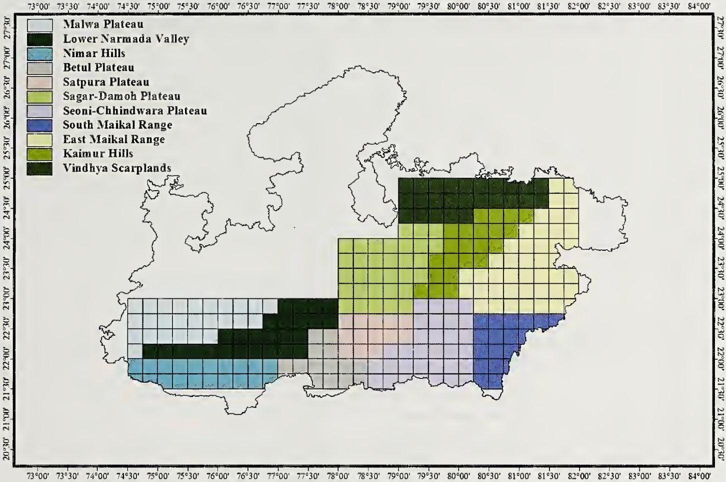
Study area

The study was conducted in Central Indian Highlands in Madhya Pradesh, which comprise the Satpura and the Vindhya ranges, and extend over an area of about 200,000 sq. km. The mean elevation of the hill ranges varies between 200-800 m, while some of the peaks in the western and central ranges exceed 1,000 m. The natural vegetation is predominantly made up of tropical dry- and moist-deciduous forests, characterized respectively by associations of teak (*Tectona grandis*) in western and central parts, and sal (*Shorea robusta*) in the east. These forests cover about 29% of the total land area (Source: IRS 1D-LISS III and FSI). There are 20 Protected Areas (i.e., 6 national parks and 14 wildlife sanctuaries) in the landscape and they occupy about 13% of the total forest area.

The study area was gridded into quarter-degree cells (15'x15') or quadrats (corresponding to Survey of India's 1:50,000 scale toposheets), with each quadrat measuring about 27 x 26.5 km in size (*c.* 715 sq. km.). This generated 284 contiguous grid-cells in total, and these quadrats formed the primary sampling units at which bird species richness and composition were mapped. To facilitate systematic bird surveys, these quadrats were grouped, *a priori*, into 11 coterminous landscape units ('regions') on the basis of natural vegetation, drainage, topography, and eco-climatic attributes, as follows: Malwa Plateau, Nimar Hills, Lower Narmada Valley, Betul Plateau, Sagar-Damoh Plateau, Satpura Plateau, Seoni-Chhindwara Plateau, Vindhya Scarplands, Kaimur Hills, East Maikal Range, and South Maikal Range (Fig. 1).

Birds

Data on species richness and composition of land birds that were known to breed in each quadrat were collected between April and July during 2002-2005. As the study area was too expansive to cover within a short period, we adopted a spatially hierarchical sampling protocol for each region with the following components: i) identification and mapping of key vegetation/habitat types in all the quadrats, ii) inventory-survey of breeding birds in each of the key vegetation types, and iii) within-region interpolation of species occurrence for all the quadrats from both these information layers. Accordingly, we collected data on bird-habitat associations from 36 major vegetation types using 'standardized area search method'. This technique involved laying of 5 ha transect-blocks in homogeneous forest types and inventorying all the bird species that were presumably breeding in the site by careful and meticulous search-walks till all the species were detected (see Jayapal *et al.* 2009 for details). In addition, numerous on-foot surveys were also undertaken to supplement the transect data, particularly in regions that were not covered by stratified sampling and in a few undersampled forest types. Matrices on bird-vegetation associations were then constructed for each region from these field-surveys. In the meantime, land cover information describing vegetation type and land use patterns were extracted from ground-truthed data collected from GPS-aided surveys in nearly all the quadrats. We also used the Survey of India's 1:250,000 and 1:50,000 toposheets to classify and estimate the extent of habitat/vegetation types in all the quadrats. Using both bird-vegetation matrices and vegetation maps generated for a region, data on distribution of breeding birds were spatially interpolated for each quadrat within the region. The final product comprising presence/absence data of bird species for each of the 284 quadrats was, later, contrasted with standard guides to birds of the Indian subcontinent (Ali and Ripley 1983; Grimmett *et al.* 1998; Rasmussen and Anderton 2005) and


Malwa Plateau
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Nimar Hills
Betul Plateau
Satpura Plateau
Sagar-Damoh Plateau
Seoni-Chhindwara Plateau
South Maikal Range
East Maikal Range
Kaimur Hills
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20°30' 21°00' 21°30' 22°00' 22°30' 23°00' 23°30' 24°00' 24°30' 25°00' 25°30' 26°00' 26°30' 27°00' 27°30'

Fig. 1: Study area comprising Central Indian Highlands in Madhya Pradesh showing the quarter-degree cells and regions as classified in the study

with various regional bird lists for Central India published in the *Journal of the Bombay Natural History Society* (see Jayapal *et al.* 2005 for a list of these published resources). The comparison was necessary to check for gaps in species distribution maps as generated by our field surveys and to ascertain if the gaps were either due to sampling inadequacy or to recent fragmentations. If it was indeed the former (as would typically be expected of widespread and habitat-generalist species), we corrected for the gaps in the data.

Though the field-surveys targeted all the land bird species that were known to breed regularly in Central Indian Highlands, several species were excluded from the final analysis owing to insufficient data. These included all the three species of Buttonquail (*Turnix* spp.), Asian Palm-Swift (*Cypsiurus balasiensis*), Brahminy Kite (*Haliastur indus*), Forest Owlet (*Heteroglaux blewitti*), Ashy Woodswallow (*Artamus fuscus*), White-bellied Minivet (*Pericrocotus erythropygius*), Spotted Creeper (*Salpornis spilonotus*), and Green Avadavat (*Amandava formosa*). In total, 190 species of land birds for which we had adequate data were included in the analysis.

Data analysis

The data matrix describing the occurrence of 190 species of birds in 284 quadrats was first subjected to hierarchical clustering to classify the quadrats into biomes. As the data was binary in nature, Sørenson's distance measure was used in conjunction with flexible beta linkage ($\beta = -0.25$) to extract the clusters. This combinatorial strategy is often recommended as it turns out to be the most space-conserving clustering algorithm for binary data (McCune and Grace 2002). However, the actual number of statistically significant clusters present in the dataset would still remain unresolved, and we concurrently used Indicator Species Analysis (ISA) to choose the optimal number of biomes from the cluster dendrogram (Dufrêne and Legendre 1997; McCune and Grace 2002).

ISA is a non-parametric technique in which indicator value of a species for a given biome is computed as the product of 'faithfulness' (proportion of sites/samples within the biome in which the species is present) and 'exclusivity' (inverse of the total number of biomes in which the species occurs), expressed as percentage. The values range from zero (poorest

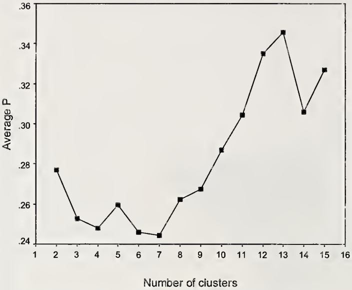

Fig. 2: Scatterplot showing the change in mean *P*-values of indicator values of bird species in response to different levels of clusters of quadrats

indicator) to 100% (perfect indicator). The statistical significance of indicator values is estimated by means of Monte Carlo randomizations. In order to ascertain the number of significant clusters to be extracted from the classification output, multiple runs of cluster analyses are carried out over a specified range of cluster-levels (usually from a few clusters higher than the 'expected level' down to two clusters). At each level of clustering, indicator values and their associated *P*-values of all the bird species are calculated and averaged across the biomes. The optimal number of clusters would then be determined as the one at which either the mean indicator value is noted to be the highest or the mean *P*-value is observed to be the lowest [see McCune and Grace (2002) for further details].

Accordingly, we ran a series of clustering (from 15 to 2 clusters) to classify the quadrats into biomes, and means of both indicator values and *P*-values (with 999 randomizations) were computed at each cluster level. The lowest *P*-value was used as the criterion to set the number of biomes to be identified and extracted. Both the cluster analysis and ISA were performed in the statistical program PC-ORD Version 4.0.

Quadrats representing different biomes were then mapped along with the existing PA network to calculate the proportion of area currently under legal protection in each biome. For this, the area of PA network in each biome was computed and contrasted with the total biome area [as estimated from Forest Survey of India toposheets and UMD-GLCF data (Hansen *et al.* 2000)]. If a PA was to be found extending over more than one quadrat, the area of the PA in

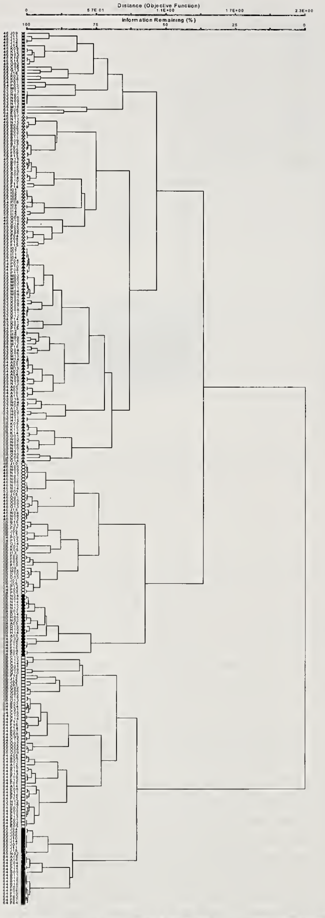

Fig. 3: Dendrogram showing the classification of quadrats (N = 284) into seven distinct biomes on the basis of bird species assemblages in Central Indian Highlands

Table 1: Major indicator birds of the four forest biomes of Central Indian Highlands along with their indicator values (IV) and associated _P_-values as estimated by ISA. Species marked * are endemic to the Indian subcontinent

Biome	Indicator Species	IV (%)	_P_
High-elevation moist deciduous forest	1. Emerald Dove _Chalcophaps indica_	62	0.001
	2. Brown Hawk-Owl _Ninox scutulata_	62	0.001
	3. Hair-crested Drongo _Dicrurus hottentottus_	61	0.001
	4. Puff-throated Babbler _Pellorneum ruficeps_	60	0.001
	5. Oriental Scops-Owl _Otus sunia_	58	0.001
	6. Brown-cheeked Fulvetta _Alcippe poioicephala_	58	0.001
	7. Indian Scimitar-Babbler _Pomatorhinus horsfieldii_*	58	0.001
	8. Malabar Pied Hornbill _Anthracoceros coronatus_*	58	0.001
	9. White-throated Fantail _Rhipidura albicollis_	57	0.001
	10. Rufous Woodpecker _Micropternus brachyurus_	56	0.001
	11. Streak-throated Woodpecker _Picus xanthopygaeus_	56	0.001
	12. Bonelli's Eagle _Hieraaetus fasciatus_	54	0.001
	13. Oriental Turtle-Dove _Streptopelia orientalis_	54	0.001
	14. Malabar Whistling-Thrush _Myophonus horsfieldii_*	53	0.001
	15. Ashy Drongo _Dicrurus leucophaeus_	52	0.001
Low-elevation moist deciduous forest	1. Greater Racket-tailed Drongo _Dicrurus paradiseus_	42	0.001
	2. Gold-fronted Leafbird _Chloropsis aurifrons_	41	0.001
	3. Tickell's Flowerpecker _Dicaeum erythrorhynchos_*	40	0.001
	4. Orange-headed Thrush _Zoothera citrina_	37	0.001
	5. Black-naped Blue Monarch _Hypothymis azurea_	37	0.001
	6. Drongo Cuckoo _Surniculus lugubris_	36	0.001
	7. Changeable Hawk-Eagle _Spizaetus limnaeetus_	35	0.001
	8. Black-hooded Oriole _Oriolus xanthornus_	35	0.001
	9. Red Junglefowl _Gallus gallus_	34	0.001
	10. Crested Serpent-Eagle _Spilornis cheela_	32	0.001
High-rainfall teak forest	1. Collared Scops-Owl _Otus bakkamoena_	27	0.001
	2. Jungle Owlet _Glaucidium radiatum_	27	0.001
	3. Black-backed Flameback _Chrysocolaptes festivus_*	26	0.001
	4. Pallas's Fish-Eagle _Haliaeetus leucoryphus_	26	0.001
	5. Indian Pitta _Pitta brachyura_*	26	0.001
	6. Indian Grey Hornbill _Ocyceros birostris_*	23	0.001
	7. Plum-headed Parakeet _Psittacula cyanocephala_*	22	0.001
	8. White-bellied Drongo _Dicrurus caerulescens_*	22	0.001
	9. Yellow-fronted Pied Woodpecker _Dendrocopos mahrattensis_	20	0.001
	10. Grey-bellied Plaintive Cuckoo _Cacomantis passerinus_*	20	0.001
Low-rainfall teak forest	1. Tawny-bellied Babbler _Dumetia hyperythra_*	26	0.001
	2. Oriental Honey-Buzzard _Pernis ptilorhyncus_	24	0.001
	3. Jungle Prinia _Prinia sylvatica_*	23	0.001
	4. White-eyed Buzzard _Butastur teesa_	21	0.001
	5. Jungle Bush-Quail _Perdicula asiatica_*	20	0.001
	6. Indian Pygmy Woodpecker _Dendrocopos nanus_*	20	0.001
	7. Small Minivet _Pericrocotus cinnamomeus_	20	0.001
	8. White-browed Fantail _Rhipidura aureola_	20	0.001

each quadrat would be calculated separately. This was necessary, as a PA might sometimes stretch across two adjacent quadrats, which were assigned to two different biomes in the analysis. We applied the IUCN's target of 10% area (Locke and Dearden 2005) as the minimum benchmark for assessing the adequacy of PA network in each biome.

RESULTS

Classification of biomes

When the pooled means of _P_-values associated with the indicator values of bird species, as computed by ISA, were examined against the number of cluster-levels of quadrats, the lowest _P_-value was obtained for seven clusters

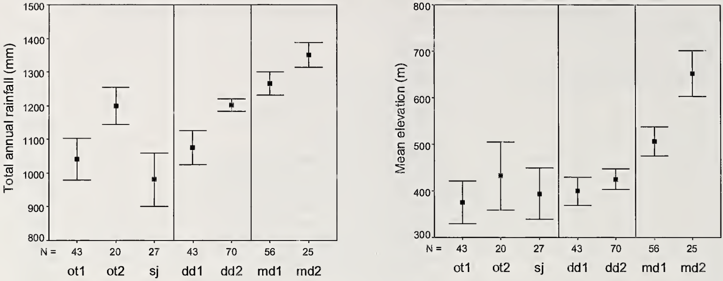

Fig. 4: Comparison of environmental attributes of the seven biomes as obtained in the hierarchical clustering of quadrats based on bird distribution. The error bars correspond to lower and upper 95% CI about the mean. The abbreviations of biomes are as follows: ot = open tracts, sj = scrub jungle, dd = teak-dominant deciduous forests, and md = moist deciduous forests

(Fig. 2). Subsequently, a final run of cluster analysis with *a posteriori* solution of seven clusters was carried out. It was evident from the resulting dendrogram (Fig. 3) that these seven groups corresponded to four vegetation types (as deduced from the UMD-GLCF land cover/use data): open tracts, scrub jungle, teak-dominant deciduous forest, and moist-deciduous forest. To aid further interpretation of the clusters, the relative positions of these groups along some environmental gradients were examined by comparison of group-means and degree of overlaps in 95% confidence intervals (CI) about the mean. The clusters were observed to differ significantly along either rainfall or elevation (Fig. 4), implying the following seven biomes: open moist tract, open semi-arid tract, scrub jungle, low-rainfall teak forest, high-rainfall teak forest, low-elevation moist deciduous forest, and high-elevation moist deciduous forest. Out of these, only four biomes were considered for further investigations into adequacy of PA network. Open tracts and scrub jungle were omitted from analysis as they were essentially human-modified environments dominated by generalist and commensal species of birds.

Table 2: The proportion of area under PA network in each of the four forest-biomes of Central Indian avifauna.

Biome	Total forest area (sq. km)	Forest area under PAs (sq. km)	% Area under PA network
High-elevation moist deciduous forest	9,512	1,876	19.72 %
Low-elevation moist deciduous forest	18,741	2,256	12.04 %
High-rainfall teak forest	16,501	1,975	11.97 %
Low-rainfall teak forest	8,883	607	6.83 %

Indicator species of biomes

Indicator values (IV) of all the bird species were computed in ISA for each biome and only those species with statistically significant values ($P < 0.01$) were considered for further screening. Species were assigned as indicator taxa to the biome for which the IV was observed to be the largest. Of all biomes, high-elevation moist deciduous forest was characterized by species with very high indicator values. On the contrary, both the biomes of teak forests were marked by generally low mean indicator values (Table 1).

Adequacy of PA network

When the boundaries of the existing PAs, comprising national parks and wildlife sanctuaries, were overlaid on the map of quadrats representing the four biomes, it was observed that all the biomes were adequately covered under PA network (i.e., > 10% of area) barring the low-rainfall teak forest with a shortfall of about 3% area as per IUCN norms. In contrast, the high-elevation moist deciduous forest had a fairly large proportion of area (*c.* 20%) under protection (Table 2).

DISCUSSION

The study amply demonstrates the potential of Indicator Species Analysis in eliciting the structure and composition of biome-restricted assemblages of species in a landscape, and how these faunal assemblages and biomes can be objectively used in assessing the adequacy of conservation efforts in the region. Analysis of geographical distribution of the breeding land birds in Central Indian Highlands using hierarchical clustering and ISA has revealed presence of seven distinct landscape units. These biomes representing unique assemblages of central Indian avifauna are evidently organized along three environmental gradients: vegetation, elevation and rainfall. The role of environment in structuring vegetation communities and secondarily the associated faunal assemblages has been acknowledged as one of the unfailing patterns in macroecology (Hawkins *et al.* 2003; Whittaker *et al.* 2005).

The tropical seasonal forests of central India show a marked gradient of moisture ranging from extremely dry vegetation in the west (e.g., Malwa Plateau) to moist forests in the south-east (e.g., Maikal Ranges), heavily influencing the composition and proportion of floristic associations alongside. For example, sal (*Shorea robusta*) dominates the climax vegetation of the moist deciduous forests in the east and south-eastern parts of Madhya Pradesh, and teak (*Tectona grandis*) forms core of the vegetation associations among the dry deciduous forests in central and western parts of the state. These changes in floristic composition are often accompanied by corresponding changes in bird composition as well, sometimes mediated through species replacements, within closely related sister-taxa [e.g., Red Junglefowl (*Gallus gallus*) in the sal, and Grey Junglefowl (*Gallus sonneratii*) in the teak biotopes]. Not surprisingly, forest physiognomy emerges in the study as a key ecological factor that defines the biomes of Central Indian Highlands. In addition, birds of moist deciduous forests show two distinct assemblages in response to elevational gradient, and differences in rainfall seem to describe the two biomes of teak forests.

Among the four forest biomes of central Indian avifauna, high-elevation moist deciduous forests are characterized by bird species with extraordinarily high indicator values, signifying the uniqueness of the biome with a large number of biome-specialists (IV > 50% for 17 species). These include Malabar Pied Hornbill (*Anthracoceros coronatus*), Oriental Scops-Owl (*Otus sunia*), Ashy Drongo (*Dicrurus leucophaeus*), Malabar Whistling-Thrush (*Myophonus horsfieldii*), Velvet-fronted Nuthatch (*Sitta frontalis*), Red-whiskered Bulbul (*Pycnonotus jocosus*), Spotted Babbler (*Pellorneum ruficeps*), Indian Scimitar-Babbler (*Pomatorhinus horsfieldii*), and Brown-cheeked Fulvetta (*Alcippe poioicephala*). Biogeographically, birds of high-elevation moist deciduous forest biome are significant as they represent remnants of the avifauna of wet humid montane forests of the past that acted as a dispersal highway for Indo-Malayan fauna from the Eastern Himalayas to the Western Ghats according to the 'Satpura Hypothesis' (Ali 1949; Karanth 2003).

The low-elevation moist deciduous biome is noteworthy for its regional importance as it is by far the most dominant in area of extent in Central Indian Highlands. Though the cumulative mean indicator value of the biome is marginally less than its high-elevation counterpart, some species of birds do show a great degree of affinity with indicator values exceeding 40%. Prominent among the birds that almost exclusively breed in low-elevation moist deciduous forests are Red Junglefowl (*Gallus gallus*), Drongo-Cuckoo (*Surniculus lugubris*), Indian White-rumped Spinetail (*Zoonavena sylvatica*), Changeable Hawk-Eagle (*Spizaetus cirrhatus*), Gold-fronted Leafbird (*Chloropsis aurifrons*), Black-naped Blue Monarch (*Hypothymis azurea*), and Chestnut-bellied Nuthatch (*Sitta castanea*).

Unlike the avifauna of moist-deciduous forests, both the high- and low-rainfall biomes of teak forests are generally marked by bird species with moderate indicator values. However, they form one of the most ubiquitous assemblages of birds that one encounters in the central Indian landscape. In fact, high-rainfall teak forests are second only to low-elevation moist deciduous forests in geographical extent, covering over an area of nearly 16,000 sq. km. An interesting feature common to indicator birds of both the teak forest biomes is that they shelter a good proportion of species endemic to the Indian subcontinent [e.g., Black-backed Flameback (*Chrysocolaptes festivus*), Indian Grey Hornbill (*Ocyceros birostris*), Indian Pitta (*Pitta brachyura*), White-bellied Drongo (*Dicrurus caerulescens*) among the breeding birds of high-rainfall teak biome, and Jungle Bush-Quail (*Perdicula asiatica*), Indian Pygmy Woodpecker (*Dendrocopus nanus*), Jungle Prinia (*Prinia sylvatica*), and Tawny-bellied Babbler (*Dumetia hyperythra*) in low-rainfall teak forest biome]. This is probably a reflection of the fact that forests in the Subcontinent are chiefly dry deciduous in nature. Thus, the preponderance of endemic species as indicator taxa makes both high- and low-rainfall biomes of teak forests biologically significant and calls for adequate conservation measures.

Indicator Species Analysis is a promising tool in macroecological applications, and is being increasingly used in place of classification and ordination methods (Dufrêne and Legendre 1997; Orrock *et al.* 2000; Heino *et al.* 2003; Venier and Pearce 2005). One of the reasons for its popularity is that ISA is relatively free of many of the key assumptions and data-constraints traditionally associated with multivariate techniques; for example, assignment of a species to a biome in ISA is independent of occurrence or abundance of other members of the assemblage unlike TWINSPAN (Dufrêne and Legendre 1997), and ordination method like Canonical Correspondence Analysis would require unimodal response of species to environmental gradients, an assumption often difficult to meet with ecological data (McCune and Grace 2002; Reyers *et al.* 2002). Some of the other emergent properties of ISA that favour its widespread use are: straightforwardness of distribution algorithms, flexibility with presence/absence data, tractability of computations, use of objective criteria to identify and retrieve indicator species, incorporation of randomization methods to evaluate statistical significance of indicator scores, and compatibility with spatial data. The present study has also demonstrated the usefulness of ISA in determining the cutoff level in a dendrogram to extract meaningful clusters, as originally proposed by Dufrêne and Legendre (1997) in their landmark paper.

Identification of biomes using multiple taxa is immensely preferable to single-species approach (e.g., umbrella or flagship species) as the latter frequently fails to ensure adequate protection for several key species and ecosystems (Roberge and Angelstam 2004; Rodrigues *et al.* 2004; McCarthy *et al.* 2006). This is well-illustrated by the findings of the current investigation in which low-rainfall teak forests emerge as the only biome in Central Indian Highlands that is under-represented in PA network. Nearly restricted to western Madhya Pradesh, these forests have been overlooked for long by PA managers evidently because they do not hold any significant populations of tiger, a species that almost solely inspires and drives conservation planning and reserve network in central India. It was, therefore, a revelation that when the critically endangered Forest Owlet (*Heteroglaux blewitti*) – a species endemic to Central India, was rediscovered in 1997 after a gap of 113 years (King and Rasmussen 1998), these low-rainfall teak forests were found to be its core habitat (contrary to original descriptions of 19th century records). The fact that a majority of these sites which are currently holding the fragmented populations of Forest Owlet lie outside PA network (Ishtiaq and Rahmani 2000; Mehta *et al.* 2007) highlights the severe bias in reserve planning in Central Indian Highlands. Though the landscape boasts of 13% forest area under PA network, they are not equitably distributed across different biomes. For example, high-elevation moist deciduous forests have a remarkably high proportion of about 20% area under the network exceeding the IUCN's minimum requirement. It is also to be noted here that all the PAs in this biome, including Kanha and Bori-Satpura Conservation Areas, were created almost exclusively for the cause of the tiger, and these PAs are marked by areas (*c.* 1,500 and 1,050 sq. km respectively) much larger than the average area of PAs (383.2 sq. km) in Central India. Despite this prejudice, it is heartening to find that all the biomes of central Indian avifauna, barring low-rainfall teak forest, are adequately protected with more than 10% of area in each biome currently under PA network. Ironically, this is again attributed to the arguable role played by charismatic taxa like tiger. It serves to highlight the political relevance of flagship species in our conservation efforts even as we begin to recognize the need for multi-species approach (see Walpole and Leader-Williams 2002).

The application of Indicator Species Analysis in conjunction with reserve selection algorithms has gained widespread approval for its biome-oriented approach to rationalization of PA network. However, this approach suffers from a conceptual issue in the sense that most of the studies are invariably restricted to a particular taxon and congruence across different taxa in spatial patterns of species diversity or endemism is not always supported by empirical data (Prendergast *et al.* 1993; Hopkinson *et al.* 2001; Rey Benayas and de la Montaña 2003). Future studies should, therefore, strive to reach solutions universally applicable to all major taxa by developing appropriate sampling protocols that would require data on distribution of multiple taxa from a landscape.

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ILLUSTRATED CHECKLIST OF OPISTHOBRANCH FAUNA OF RATNAGIRI, MAHARASHTRA, INDIA, WITH EIGHT NEW RECORDS TO INDIA

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The Ratnagiri coast is among the least studied areas for marine life in India. The coast is known to host a high diversity of marine habitats, and flora and fauna. Opisthobranchs have received attention only recently, Maharashtra coast being the least explored. The paper presents 16 species of opisthobranch of which 15 are new records to Maharashtra and 8 to India.

Keywords: Nudibranchs, Konkan, Aeolid, Dorid, Sacoglossa, intertidal

INTRODUCTION

Studies on the Opisthobranch fauna of Maharashtra are limited to a few publications by Balani and Patel (1994); Hornell (1909, 1951); Kasinathan *et al.* (1975) and Winckworth (1946a,b). On the west coast of India, most of the work on Opisthobranch is confined to the Gulf of Kutch and Lakshadweep. It includes work by Apte (2009); Apte *et al.* (2010); Apte and Salahuddin (2010); Balani and Patel (1994); Fontana et al. (2001), Gideon *et al.* (1957); Hornell (1909, 1951); Jagtap *et al.* (2009); Menon *et al.* (1970); Narayanan (1968, 1969, 1971a,b); Patil (1952); Rudman (1980); and Valdés *et al.* (1999). The present study was carried out in Ratnagiri, Maharashtra, India.

STUDY AREA

Ratnagiri is located at 16.98° N and 73.3° E on the west coast of India, Arabian Sea (Fig. 1). Patchy reefs are present near Ratnagiri in intertidal areas and occasionally at sub-tidal depths. Sampling was mostly done in rocky areas with a few sandy patches.

The intertidal area is rich in alga like *Caulerpa racemosa*, *C. peltata*, *C. taxifolia*, *Sargassum* sp., *Dictyota* sp., *Padina* sp., *Ulva* sp., *Avrainvillea* sp., etc. Many types of cnidarians (anemone, hydroids, corals and soft coral), bryozoan species of genus *Membranipora* and *Electra* are more common. Also, many species of sponges and other associated invertebrates, like nemertean worm and flatworms could be observed.

METHODOLOGY

Opisthobranchs were searched during low tides and a few specimens were collected for reference. The reference specimens were preserved in ethyl alcohol after studying the morphological characters in live condition. Digital images of live specimens of each species were taken to record true colours. Wherever possible, notes on egg cases were made. Specimens were deposited in the Collection of the Bombay Natural History Society. Field collection was carried out from November 2008 to March 2009.

RESULTS AND DISCUSSION

During the five month study a total of 16 species were recorded belonging to 12 families. Of these, 15 species are new records to Maharashtra and 8 to the Indian coast. Table 1 summarizes the findings. This indicates that the opisthobranch fauna in India, particularly in Maharashtra, is the least studied. A comprehensive assessment is thus necessary to reveal the true diversity of this group. The Ratnagiri coast with its excellent rocky shores and abundant variety of algae, sponges and hydroids, provides an ideal habitat for opisthobranch fauna. Shallow rock pools provide highly specialized niche for shade loving hydroids. Thus, at certain locations, hydroid affiliated aeolids, e.g., *Phidiana militaris*, *Phidiana anulifera* and *Anteaeolidiella indica* are present in abundance. Sponge feeding *Sebadoris fragilis* and *Dendrodoris fumata* are also present in abundance.

Family: Aplysiidae

Aplysia oculifera Adams & Reeve 1850

India: This is the first record of this species from India.

Extralimital Distribution: Indo-West Pacific, South Africa, Sri Lanka, Red Sea.

Size: 60 & 80 mm (Two specimens).

Description: A large animal usually seen in congregations; mostly seen in shallow waters during receding tides in algal masses. It is greenish-brown with small brown spots. Inner side of mantle is spotted with white (Fig. 2).

Egg mass: The noodle-shaped egg ribbon is greenish-brown.

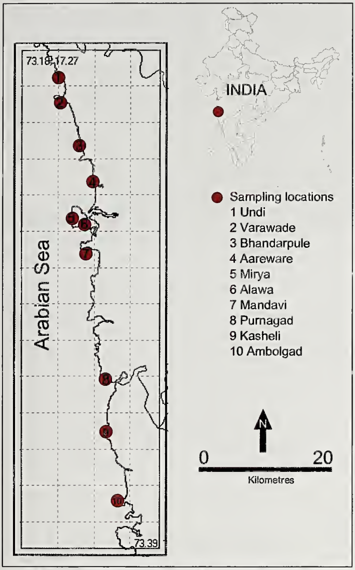

Fig. 1: Sampling sites at Ratnagiri, Maharashtra, India. (coordinates: 73.18, 17.27; 73.39, 16.57)

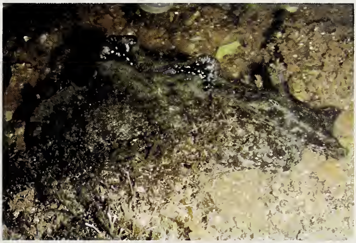

Fig. 2: *Aplysia oculifera*

Occurrence: Seasonal, particularly from December through April.

Family: Plakobranchidae

***Elysia expansa* (O'Donoghue 1924)**

India: Ratnagiri.

Extralimital Distribution: South Africa, Indo-West Pacific.

Size: 12-60 mm (37 specimens).

Description: Usually found on *Caulerpa* beds, this species is characterized by large green parapodia. It is deep green to pale yellow, depending upon its feeding state. The parapodium is margined by a black line. Rhinophores are pale brown and tubular (Fig. 3).

Radula: Radular blade is knife-like and flat. Total numbers of teeth are 16 (Figs. 3.2, 3.3).

Table 1: Opisthobranch fauna of Ratnagiri

Sr. No	Family	Species	New Record to Maharashtra	New Record to India
1.	Aplysiidae	*Aplysia oculifera* Adams & Reeve, 1850	v	v
2.	Plakobranchidae	*Elysia expansa* (O'Donoghue, 1924)	v	-
3.	Polyceridae	*Thecacera pennigera* (Montagu, 1815)	v	v
4.	Polyceridae	*Plocamopherus ceylonicus* (Kelaart, 1858)	v	-
5.	Chromodorididae	*Chromodoris naiki* Valdés, Ernesto & Ortea 1999	v	-
6.	Discodorididae	*Sebadoris fragilis* (Alder & Hancock, 1864)	v	-
7.	Discodorididae	*Carminodoris* sp.	v	v
8.	Dendrodorididae	*Dendrodoris fumata* (Rüppell & Leuckart, 1831)	v	-
9.	Bornellidae	*Bornella stellifer* (Adams & Reeve, 1848)	v	-
10.	Tritoniidae	*Marionia* cf *olivacea*	v	v
11.	Eubranchidae	*Eubranchus mandapamensis* Rao, 1968	v	-
12.	Eubranchidae	*Eubranchus* sp.	v	v
13.	Facelinidae	*Phidiana militaris* (Alder & Hancock, 1864)	-	-
14.	Facelinidae	*Phidiana anulifera* (Baba, 1949)	v	v
15.	Aeolidiidae	*Anteaeolidiella indica* (Bergh, 1888)	v	v
16.	Costasiellidae	*Costasiella* cf *kuroshimae*	v	v
			15	8

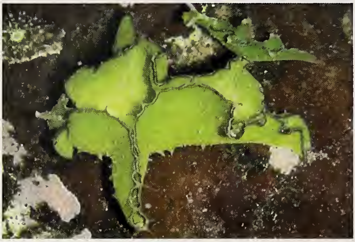

Fig. 3: *Elysia expansa*

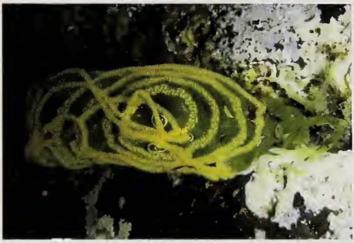

Fig. 3.1: *Elysia expansa*: Egg case on *Caulerpa scalpelliformis*

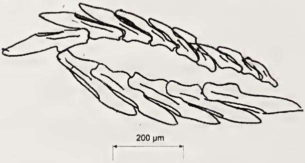

Fig. 3.2: *Elysia expansa*: Radula

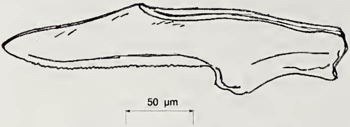

Fig. 3.3: *Elysia expansa*: Single radular tooth

Egg mass: The extracellular yolk embedded within the transparent eggs make the egg mass appear like a yellow coil. Egg masses are usually laid on various substrata, e.g., fronds of *Caulerpa* and other green algae, and sometimes on walls of rock pools (Fig. 3.1).

Occurrence: Seasonally common (between November through March).

***Plocamopherus ceylonicus* (Kelaart 1858)**

India: Ratnagiri, Alibaug (Maharashtra), South Gujarat, Gulf of Mannar (Tamil Nadu).

Extralimital Distribution: Australia, Singapore, Philippines, Indonesia, Marshall Island.

Size: 6-36 mm (Seven specimens, one dissected for radula).

Description: These slugs are found under rocks. Head bears an oral veil, a dermal process protruding from the anterior part of the head. There are 3 pairs of papillae on either side of the body; the 2nd pair from the gill has pink rounded knobs (Fig. 4), which are known to emit light when disturbed. We have seen this behaviour in the specimens collected from Mumbai and Gulf of Kutch, but not in the specimens from Ratnagiri. Foot and mantle bear bright orangish-yellow spots. Foot is extended to form a tapering tail, which is used for swimming when disturbed.

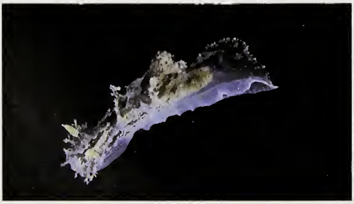

Fig. 4: *Plocamopherus ceylonicus*

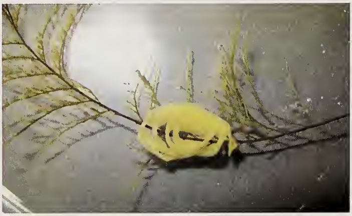

Fig. 4.1: *Plocamopherus ceylonicus*: Egg case

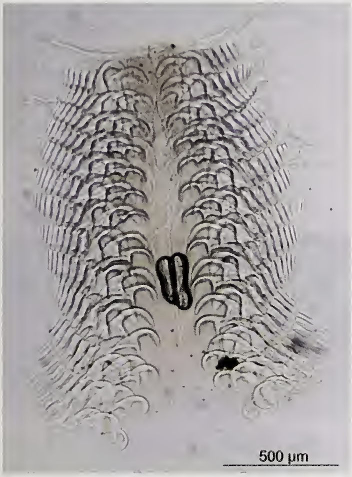

Fig. 4.2: *Plocamopherus ceylonicus*: Radula

Radula: Radular formula: 13 x 7.3.0.3.7 (Figs. 4.2, 4.3).

Egg mass: Egg case is a yellow rosette, with large yellow eggs embedded in the gelatinous sheath (Fig. 4.1).

Occurrence: Seasonally common (between October through April).

Family: Polyceridae

Thecacera pennigera (Montagu 1815)

India: This is the first record of this species from India.

Extralimital Distribution: A widely distributed species, it is recorded from British Isles, Australia, Korea, Japan, New Zealand, Netherlands, Senegal, Israel, Pakistan, West Africa, Brazil, South Africa (NIMPIS 2002).

Size: 8-18 mm (Five specimens).

Description: A small sea slug, the foot is short, yellow, and spotted with tiny orange and black spots. Body appears speckled with white dots/rodlets. Broad head has two pointed lateral extensions. Rhinophores are contained within the flared rhinophore sheaths – a diagnostic feature of the species. The rhinophore sheath and gills are covered by orange and black spots (Fig. 5).

Egg mass: The white ribbon-like egg case is laid on bryozoans, the main food source of the species. The ribbon is about 0.8 cm wide (Fig. 5).

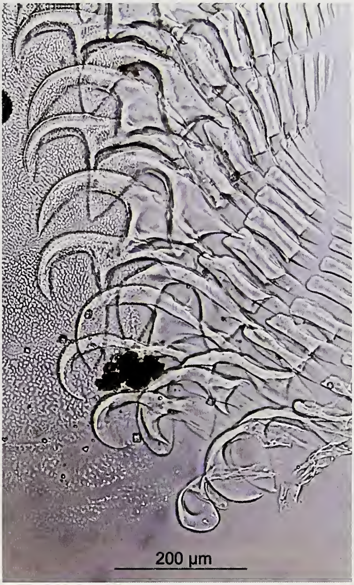

Fig. 4.3: *Plocamopherus ceylonicus*: Radula (right half side)

Occurrence: Uncommon and seasonal (between December through April).

Family: Chromodorididae

Chromodoris naiki Valdés, Ernesto and Ortea 1999

India: This is the first record from Ratnagiri. The species was described from the Gulf of Mannar (Valdés *et al.* 1999).

Extralimital Distribution: Thailand.

Size: 3-16 mm (Three specimens).

Description: A tiny sea slug from rocky reefs, the base colour is white with a highly decorated surface. Margin is deep orange lined by a row of deep purple spots. Dorsal surface is profusely speckled with silver spots. Rhinophores, foot and gills are also speckled with silver spots. Foot is short and white in colour. It differs from *C. naiki* in: specimen from Ratnagiri has 7 gills (as against 6 in *C. naiki*); orange spots mostly confined to a sub-marginal mantle band. We are

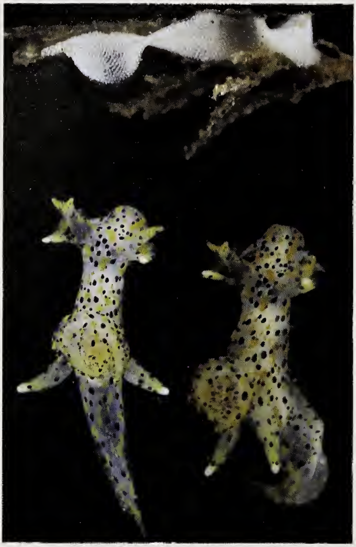

Fig. 5: *Thecacera pennigera* with egg case

currently considering it as a regional variation of *C. naiki* (Fig. 6).

Another similar species – *Chromodoris bombayana* Winkworth 1946 – is described from much closer to the current locality. *Chromodoris bombayana* has black spots and white speckles; speckles are clearly seen in both the specimens from Ratnagiri as well as the specimen described by Valdes *et al.* (1999). However, we have identified the specimen as *Chromodoris naiki* till we collect adequate specimens for anatomical studies, as well as specimens of *C. bombayana* from the type locality.

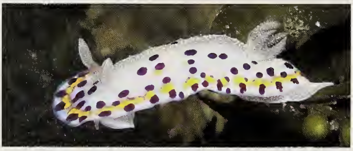

Fig. 6: *Chromodoris naiki*

Occurrence: Uncommon.

Family: **Discodorididae**

Sebadoris fragilis **(Alder and Hancock 1964)**

India: Ratnagiri (Maharashtra), Gulf of Mannar (Tamil Nadu), Waltair (Andhra Pradesh).

Extralimital Distribution: Indian Ocean, Australia, Philippines, Red Sea, Japan, South Africa, Thailand, Hawaii, New Caledonia.

Size: 15-80 mm (12 specimens).

Description: A large sea slug, it is usually seen in

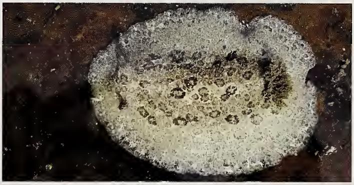

Fig. 7: *Sebadoris fragilis* (Dorsal side)

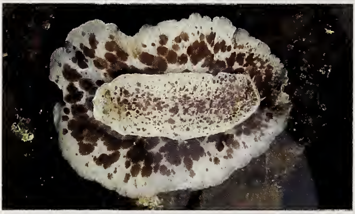

Fig. 7.1: *Sebadoris fragilis* (Ventral side)

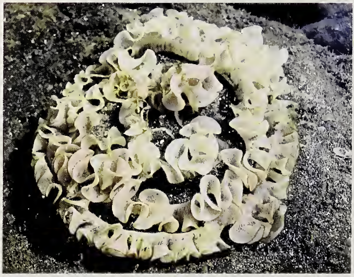

Fig. 7.2: *Sebadoris fragilis*: Egg case

shallow pools and under rocks. It prefers rocky substrate. Brown mottling is distinct on the foot (Fig. 7.1). The species can autotomise large parts of the mantle or sometimes the entire mantle skirt if disturbed. Gills are highly frilled (Fig. 7). The species was re-designated as *S. fragalis* by Dayrat (2010) in his comprehensive review of basal discodorids.

Egg mass: The yellow egg mass is a rosette. Egg ribbon is around 40 mm in diameter in larger specimens (Fig. 7.2).

Occurrence: Common (from November through April).

Carminodoris sp.

India: Ratnagiri (Maharashtra).

Extralimital Distribution: Unknown.

Size: 70-80 mm (Two specimens).

Description: A large ovate sea slug, usually seen under rocks. Mantle is covered with rounded tubercles of varying sizes. The ground colour is translucent brown with scattered dark brown patches. Tubercles are somewhat brownish with white basal band. The species has a close resemblance with *Carminodoris grandiflora* (Fig. 8).

Egg mass: Egg case is a yellowish-cream wavy ribbon around 33 mm in diameter (Fig. 8.1).

Occurrence: Uncommon.

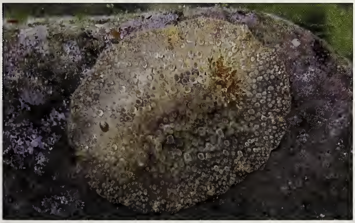

Fig. 8: *Carminodoris* sp.

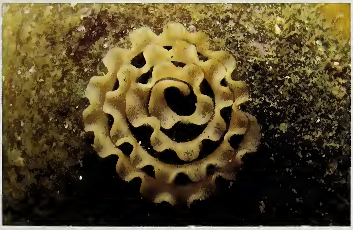

Fig. 8.1: *Carminodoris* sp.: Egg case

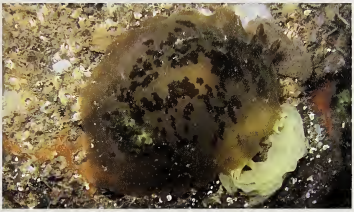

Fig. 9: *Dendrodoris fumata* with egg case

Family: Dendrodorididae

Dendrodoris fumata (Rüppell & Leuckart 1831)

India: Ratnagiri, Andaman, Gulf of Kutch.

Extralimital Distribution: Red Sea, Western Australia, Korea, New Caledonia, Seychelles, Reunion, Singapore, Japan.

Size: 8-60 mm (17 specimens).

Description: It is found mostly in shallow pools and under rocks on muddy reefs. Rhinophores have white tips. Gills are tri-pinnate. This species has a number of colour morphs: a) pale brown to deep orange in specimens around 8-20 mm; b) pale brown with patches of dark brown or vice versa in specimens around 20-40 mm; and c) pale brown with dark brown or blackish patches in specimens around 40-60 mm) (Fig. 9).

Egg mass: The yellow egg case is a rosette (Fig. 9).

Occurrence: Seasonally common (from August through May).

Family: Bornellidae

Bornella stellifer (Adams and Reeve 1848)

India: Ratnagiri and Revdanda (Maharashtra), Gulf of Kutch (Gujarat).

Extralimital Distribution: Indo-West Pacific: South China Sea, Australia, Korea, Indian Ocean, South Africa, East Africa, Philippines, Arafura Sea, China Sea, Japan, Hong Kong, Tahiti, New Caledonia, Taiwan, Thailand, Marshall Islands and Papua New Guinea (Pola *et al.* 2009).

Size: 25-40 mm (12 specimens).

Description: A small sea slug, it is found on rocky reefs. Oral tentacles are paired and fingerlike. Gills are placed at the base of each cerata. Each rhinophore is present on a long stalk and surrounded by long filamentous papillae. This slug is deep reddish-brown with white patches, tips of cerata and papillae have a red band. It feeds on hydroids. Specimens from Ratnagiri appear distinct, particularly the cerata, as

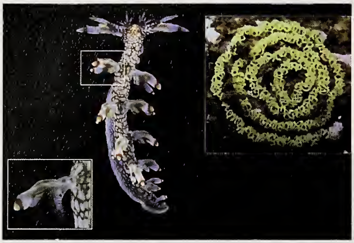

Fig. 10: *Bornella stellifer* with egg case

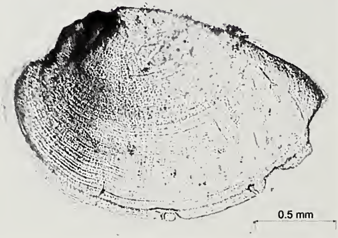

Fig. 10.1: *Bornella stellifer*. Jaw plate

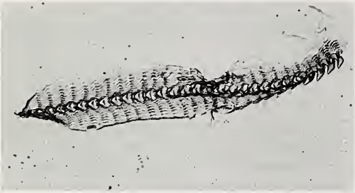

Fig. 10.2: *Bornella stellifer*. Radula

compared to specimens from Gujarat. Anatomically, however, they are the same (Fig. 10).

Egg mass: Egg mass is yellow (in daylight), with secondary coiling, and laid spirally, anti-clockwise from the centre of origin (Fig. 10).

Jaw plate: The jaw is round/oval-shaped (Fig. 10.1).

Radula: Radula formula is 34 x 8.1.8 (Fig. 10.2).

Occurrence: Common (between November through April).

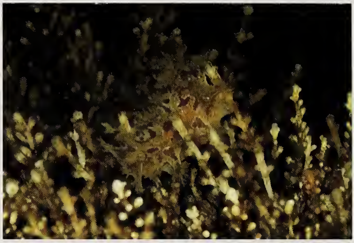

Fig. 11: *Marionia* cf *olivacea* on *Carijoa* sp.

Family: Tritoniidae

Marionia* cf *olivacea

India: Ratnagiri. This is the first record from India.

Extralimital Distribution: Indonesia, Kenya, Japan.

Size: 30-35 mm (2 specimens).

Description: Body translucent cream with dark orangish-brown pattern on the mantle. The sides of the body are pustulose with a network of orange and creamish-brown colour running between the pustules. The mantle and oral veil are essentially orange-brown with a symmetrical pattern of dark brown patches along the edge of the mantle and at the base of the gills. It was seen in a rock pool with soft coral *Carijoa* sp. (Fig. 11).

Occurrence: Occasional.

Family: Eubranchiidae

***Eubranchus mandapamensis* Rao 1968**

India: Mandapam, Ratnagiri (Maharashtra).

Extralimital Distribution: Indo-Pacific. Hawaii, Mexico.

Size: 10-15 mm (Two specimens).

Description: This aeolid has a transparent body with minute black spots speckled all over. Rhinophores are annulated with about 6-8 annuli. The cerata are larger than the body size and have two tiers of tubercles and a bulbous tip. Tips are whitish followed by three rings coloured orange, yellow, and pink respectively (Fig. 12).

Egg mass: White coloured coiled egg mass (Fig. 12).

Occurrence: Occasional.

***Eubranchus* sp.**

India: Ratnagiri (Maharashtra).

Extralimital Distribution: Not known.

Size: 1-35 mm (11 specimens).

Description: It has a transparent body with minute dark

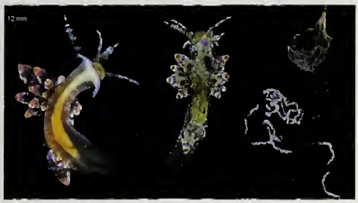

Fig. 12: *Eubranchus mandapamensis* with egg case

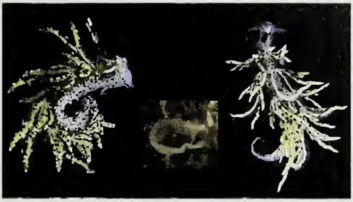

Fig. 13: *Eubranchus* sp.

yellowish-orange spots all over, except oral tentacles and rhinophores. Tips of oral tentacles and rhinophores are transparent with a pale yellow-orange band at sub-apical region. Cerata are slender and contain unbranched digestive gland (Fig. 13).

Egg mass: Egg mass is transparent, ribbon-like, 5 mm or less in height arranged in a single spiral, with large white eggs (Fig. 13). Usually seen on the underside of rocks with tiny hydroids (possibly from family Sertulariidae), on which the slug was observed to feed (Fig. 13).

Radula: Formula is 1.1.1 Median teeth with 3-4 lateral denticles on both sides. Median denticle somewhat blunt (Figs. 13.1, 13.2).

Occurrence: Uncommon (between December to March).

Family: Facelinidae

Phidiana militaris (Alder & Hancock 1864)

India: Widespread on the east and west coast of India. Gujarat, Maharashtra, Tamil Nadu, Andhra Pradesh, Andaman.

Extralimital Distribution: Malaysia, Papua New Guinea, Indo-West Pacific.

Size: 11-35 mm (18 specimens).

Description: These sea slugs are closely associated with hydroids. Cerata are transparent and digestive gland bright violet and orange. Oral tentacles and rhinophores bear a distinct Y-shaped orange band (Fig. 14).

Egg mass: White egg mass is laid spirally, usually around 20-28 mm in diameter depending upon the size of the specimen (Fig. 14).

Occurrence: Common (from October through May).

Phidiana anulifera (Baba 1949)

India: Ratnagiri (Maharashtra). It is the first record from India.

Extralimital Distribution: Malaysia, Papua New Guinea.

Size: 5-36 mm (17 specimens).

Description: A small sea slug, the body is opaque white.

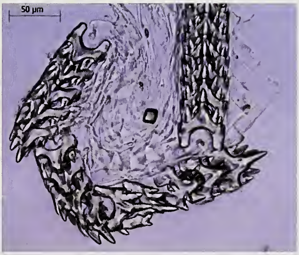

Fig. 13.1: *Eubranchus* sp.: Microphotograph of Radula

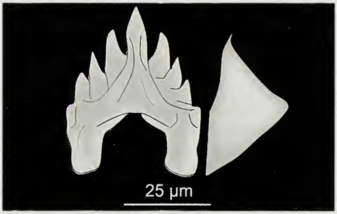

Fig. 13.2: *Eubranchus* sp.: Radula teeth

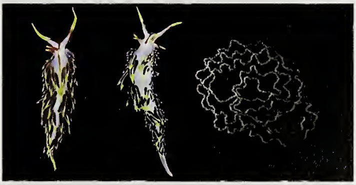

Fig. 14: *Phidiana militaris* with egg case

Oral tentacles bear a broad reddish-orange band. The rhinophores have six distinct and sharply-edged annuli, annulated region being opaque. There is a pair of thin orange lines running from the base of the oral tentacles back to the rhinophores. These lines continue to run around the back of the rhinophores and down to the first ceratal group on each side. This red-orange line reappears along the side of the body between each ceratal cluster. It also runs a short distance from the last ceratal cluster back on to the posterior foot. The cerata are pale brown primarily due to the colour of the digestive gland (Fig. 15).

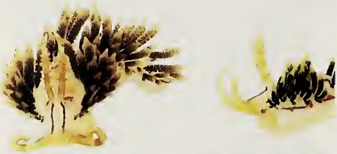
Fig. 15: *Phidiana anulifera*: (L-R): Front view and body profile, Side view

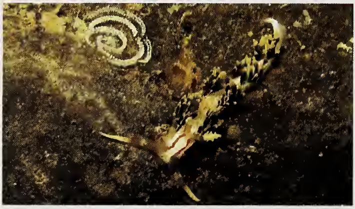
Fig. 15.1: *Phidiana anulifera*: Egg case

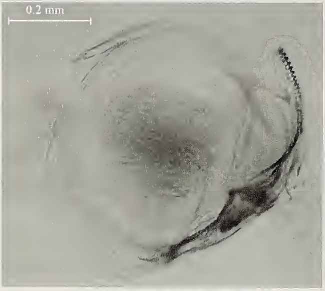

Fig. 15.2: *Phidiana anulifera*: Jaw plate

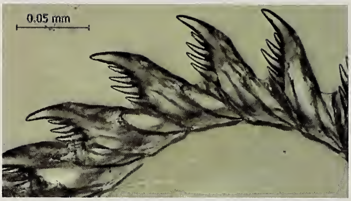

Fig. 15.3: *Phidiana anulifera*: Side view

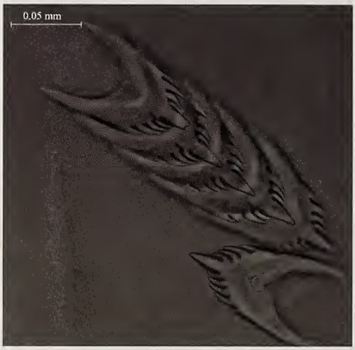

Fig. 15.4: *Phidiana anulifera*: Dorsal view of teeth

Egg mass: Egg case is white, laid in spiral with size around 6-12 mm, on or beneath the rock (Fig. 15.1).

Jaw and Radular Formula: Jaw plate rounded with serrated masticatory border (Fig. 15.2) and uni-seriate radula with 21 rows and a rachidean tooth (21-23 x 0.1.0). Each tooth has 4 denticles on each side of a median cusp. (Figs. 15.3, 15.4).

Occurrence: Common (from November through April).

Family: Aeolidiidae

Anteaeolidiella indica (Bergh 1888)

India: Ratnagiri. It is the first record from India.

Extralimital Distribution: It is widely distributed all around temperate, Indian and Pacific Oceans, Red Sea and Canary Islands, Eastern Atlantic.

Size: 6-36 mm (34 specimens).

Description: Rhinophores are smooth, finger-shaped, with white tips. Oral tentacles slightly longer than the

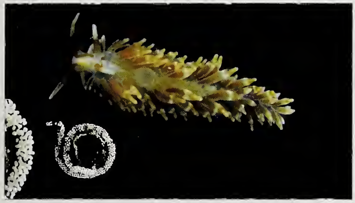

Fig. 16: *Anteaeolidiella indica* with egg ribbon

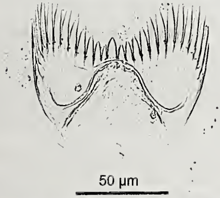

Fig. 16.1 *Anteaeolidiella indica*: Radular tooth

rhinophores. The orange pattern that outlines the white diamond-shaped marks on the dorsa is characteristic (Fig. 16).

Egg mass: Egg case is spirally coiled and white (Fig. 16).

Radula: Radular formula is 8 x 0.1.0; denticles of radular teeth vary between 7 and 12 in the 6 mm specimen. Radula looks similar to that of *Anteaeolidiella orientalis* (Bergh 1888), now a synonym of *Anteaeolidiella indica* (Bergh 1888) Gosliner and Griffiths (1981) (Fig. 16.1).

Occurrence: Common (between October through May).

Family: Costasiellidae

Costasiella cf *kuroshimae*

India: Ratnagiri.

Size: 18 and 25 mm (Two specimens).

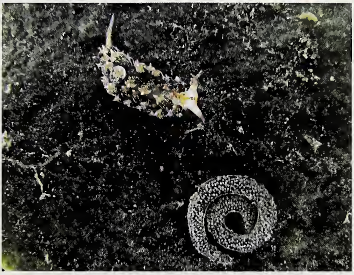

Fig. 17: *Costasiella* cf *kuroshimae* with egg case

Description: An orange-brown band on the head and between the rhinophores is diagnostic. A pair of eyes situated on the dorsal midline is characteristic of the genus. Many cerata-like structures are densely arranged on either side of the body giving it a look of an aeolid. Cerata-like structures are pinkish at the tip, translucent and greenish due to cell sap and chloroplast. The species from this genus are known to feed exclusively on green algae *Avrainvillea* sp.

Egg mass: Egg cases are spiral, white and laid on *Avrainvillea* sp. (Fig. 17).

Occurrence: Uncommon.

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Photographs: Vishal Bhave.

Deepak Apte: *Dendrodoris fumata* and *Sebadoris fragilis* egg case.

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INVENTORY OF MOTH FAUNA (LEPIDOPTERA: HETEROCERA) OF THE NORTHERN WESTERN GHATS, MAHARASHTRA, INDIA

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This paper presents an inventory of 418 species of moths (303 identified to species, 116 identified to genus) from 28 families belonging to 15 superfamilies, which were recorded by light trapping at eight sites in northern Western Ghats, India. Of the species recorded, with reference to their published distribution ranges, 11 species from five families appear to be new records for India, range extensions were noted for 130 species from 16 families, and 25 species from six families are endemic to India. The dominant families were Erebidae, Geometridae, Sphingidae and Crambidae. The highest number of moths were recorded from Malshej Ghat, Sanjay Gandhi National Park and Bheemashankar Wildlife Sanctuary. The highest species diversity was recorded from Sanjay Gandhi National Park. Amboli, Koyna Wildlife Sanctuary and Malshej Ghat showed a number of new records and seem to support interesting and endemic moth fauna. Amboli and Koyna Wildlife Sanctuary need further detailed sampling, as these areas have been largely unexplored for moths. Extensive sampling in Sanjay Gandhi National Park resulted in many range extensions for the northern Western Ghats; this indicates that if sampling is intensified additional records may also be generated at the other sites. It was concluded that the moth diversity of northern Western Ghats is similar to that of north-east India. Further systematic and intensive surveys will yield more data.

Keywords: northern Western Ghats, moths, geographical range, Maharashtra, Amboli, Bheemashankar Wildife Sanctuary, Koyna, Mahabaleshwar, Malshej Ghat, Matheran, Phansad, Sanjay Gandhi National Park

INTRODUCTION

The Western Ghats are a chain of hills stretching 1,440 km from the Tapti river north of Mumbai to the tip of the Indian peninsula at Kanyakumari. The habitat comprises of four tropical and subtropical moist broadleaf forests – the northern Western Ghats moist deciduous forest, northern Western Ghats montane rain forest, southern Western Ghats moist deciduous forest, and southern Western Ghats montane rain forest. The region receives high rainfall, which occurs primarily during the south-west monsoon. The Western Ghats are important catchment areas for nearby cities, towns and villages. The lush green environment of the Western Ghats is suitable for a wide variety of organisms. In addition to endangered plants, a large number of animals species, over 330 vertebrate species and at least 37 butterfly species (Ranjit Daniels 2003), are endemic to the Western Ghats.

The northern Western Ghats (known locally and hereafter referred to as the Sahyadris) begin in southern Gujarat and run south through Maharashtra to Goa. This part of the range is generally drier than the southern part; at lower elevations it forms the Sahyadris moist deciduous forests. The cooler and wetter Sahyadris montane rain forests occur above 1,000 m elevation. In Maharashtra, there are excellent examples of the rich Sahyadris forests, but this forest is highly fragmented and is being increasingly degraded by human exploitation. The loss and fragmentation of tropical rainforest, which holds a major proportion of the world's biodiversity, remains a crucial global conservation problem (Whitmore 1997; Kapoor 2006). There is a paucity of research on invertebrates even though they make up a significant portion of the animal diversity in tropical rainforests (Klein 1989). Also, being sensitive to environmental change, invertebrates are important indicators to help understand the effects of processes such as habitat fragmentation (Jansen 1997; Miyashita *et al.* 1998).

Ranjit Daniels (2003) records several conservation-oriented studies, mostly on plants and vertebrates, of this biodiversity hotspot. However, there is little information on invertebrates. The present preliminary study aims to make an inventory as a baseline for future studies on the moths of the Sahyadris, to enable informed conservation efforts and ecological studies of these insects in the Western Ghats. This moth survey is the first of its kind to be undertaken in the Sahyadris.

Abbreviations used in the text and tables

AM = Amboli; BMNH = Natural History Museum, London (ex. British Museum (Natural History)); BNHS = Bombay Natural History Society; BWS = Bhimashankar Wildlife Sanctuary; DD = data deficient; EN = endemic; KWS = Koyna Wildlife Sanctuary; MB = Mahabaleshwar; MG = Malshej Ghat; MN = Matheran; NR = new record for India; PWS = Phansad Wildlife Sanctuary; RE = range extension; SGNP = Sanjay Gandhi National Park; Nil: Nothing to mention.

METHODOLOGY

In 2004-2008, a study on moths was initiated and the northern Western Ghats (Sahyadris) were chosen as the study area for documenting the moth fauna. Eight sites were selected from the southern, central and northern parts of the Sahyadris on the basis of their habitat conditions, and uniqueness of their known biodiversity and bionomic status. The sites are listed in Table 1.

Moths were surveyed primarily by use of light traps, but also by day time field visits. The survey was conducted for a year and included the main moth flight season (May through October). Light traps were infrequently set up in the study areas either once a month/weekly in case of Malshej Ghat and Sanjay Gandhi National Park, wherein the light traps were operated for two consecutive nights and one night, respectively. The remaining locations were visited occasionally during the mothing season and the light traps were operated for two to four consecutive nights. This being a prelimary study the data collected was not systematic and uniform from all locations. This resulted in unequal recording effort among different sites in the study area. The most intensively surveyed areas were Sanjay Gandhi National Park and Malshej Ghat, where substantial work was carried out. The light traps were operated during new moon nights in areas with minimum illumination for good catch. Altogether, 84 light traps were set up from 2004-2008.

The light trap comprised a 3 x 4 m white cloth stretched between two posts or trees, in front of which was hung a mercury vapour light bulb (Philips, B/73, ML 160 W) (William 1987). This set-up is more suited to tropical conditions than are box or tub style traps, such as the Robinson trap or Skinner trap (Waring 1994). A portable generator (Honda, GK 200, 2.28 KW/ 3600 rpm) was used for power supply. The survey team camped in resorts with close proximity to forests; the light traps were operated overnight from 19:00 hrs to 05:00 hrs. The light traps were switched off at 05:00 hrs to allow the moths (and other insects) to disperse before sunrise, which usually happened after 05:30 hrs; this was to prevent their predation by birds (Longcore and Rich 2004).

Moths attracted to the light traps were photographed. Where necessary, a maximum of five voucher specimens per species were collected for identification. These specimens were killed in plastic containers with ethyl acetate vapour and pinned (Dickson 1992) the following day. All specimens are currently retained by the first author at the Conservation Education Centre of the Bombay Natural History Society, Mumbai. Besides data collected through light traps, photographic evidences have also been considered when listing the species.

Identification of moths and compilation of distribution ranges were carried out with the assistance of literature sources: Hampson (1892-96), Bell and Scott (1937), Holloway (1983-2005), Arora and Gupta (1979), Barlow and D'Abrera (1982), Peigler (1989), Robinson *et al.* (1994), Shubhalaxmi and Chaturvedi (1999), Kendrick (2002, 2004),

Table 1: Sites surveyed, their location, habitat

Site name	Latitude (North)	Longitude (East)	Elevation (in metres)	Habitat type
Sanjay Gandhi National Park	19° 18'-19° 21'	72° 53'-72° 58'	486	Semi-moist deciduous forest.
Malshej Ghat	19° 20'	73° 47'	500-900	High hilly region with stunted hill top vegetation and evergreen patches in deep ravines.
Bhimashankar Wildlife Sanctuary	19° 04'	73° 32'	~1,000	Southern tropical semi-evergreen forest.
Matheran	18° 57'-19° 00'	73° 15'-73° 17'	~750	Evergreen forest. Declared an ecosensitive zone.
Phansad Wildlife Sanctuary	18° 21'-18° 24'	72° 55'-72° 58'	100-200	Coastal forest ecosystem.
Mahabaleshwar	17° 55'	73° 55'	~1,350	Evergreen forest. Declared an ecosensitive zone.
Koyna Wildlife Sanctuary	17° 27'	73° 50'	600-1,100	Southern tropical evergreen forests and southern moist mixed deciduous forest.
Amboli	15° 57'	74° 00'	~750	Evergreen forest.

Pittaway and Kitching (2004), Kononenko and Pinratana (2005), Smetacek (2008) and personal communications from I.J. Kitching, based on the BMNH collection. Web-based resources used to aid identification included Herbison-Evans and Crossley (n.d.), Beccaloni *et al.* (n.d.), Beck and Kitching (n.d.), Savela (1999), Anonymous (2003), Zwier (2004), and Korea Institute of Science and Technology Information (2007). Taxonomic order follows Holloway *et al.* (1983-2000), with Noctuoidea updated to follow Lafontaine and Fibiger (2006), and Lafontaine and Schmidt (2010).

As identification of all moth species was not possible due to lack of literature and genitalia dissection facility, some were identified to genus level. Species identified to genus and superficially similar to a particular species, though identification is unconfirmed, have been referred to in the text as genus c.f. species.

RESULTS

The study recorded 418 moth taxa (303 identified to species and 116 identified to genus level) from 28 moth families belonging to 15 superfamilies. Of these, 11 species from five families are new records for India, of which maximum are from Family Erebidae (n = 4), and from Malshej Ghat (n=4). The study area details are given in Table 1.

There were 130 species from 16 families for which range extensions were recorded. Maximum range extensions were recorded from Family Erebidae (n = 47) and Malshej Ghat (n = 89). Altogether, 25 species from six families recorded were endemic to India. Maximum endemic species were recorded from Family Erebidae (n = 9) and Malshej Ghat (n = 16). Among the moth families, the highest species richness was recorded for Family Erebidae (n = 128), followed by Geometridae (n = 65) and Crambidae (n = 47) (see Table 2). Among the study sites, highest species richness was recorded for Sanjay Gandhi National Park (n = 226 in 26 families) followed by Bheemashankar Wildlife Sanctuary (n = 211 in 16 families) and Malshej Ghat (n = 239 in 15 families).

Details of individual taxa recorded are given in Table 4 Despite unequal sampling we have presented a list of all sites (Table 3). Though incomplete, this provisional list is valuable as it provides baseline data on moths of the northern Western Ghats (Table 3).

Table 2: List of Recorded Moth Families and Species

	Families	Number of Species
1.	Hepialidae	1
2.	Adelidae	1
3.	Tineidae	1
4.	Oecophoridae	2
5.	Gelechiidae	1
6.	Gracillariidae	1
7.	Lecithoceridae	1
8.	Sesiidae	1
9.	Cossidae	2
10.	Limacodidae	19
11.	Zygaenidae	2
12.	Torticidae	1
13.	Crambidae	42
14.	Pyralidae	6
15.	Thyrididae	6
16.	Pterophoridae	3
17.	Sphingidae	45
18.	Bombycidae	3
19.	Eupterotidae	4
20.	Saturniidae	5
21.	Lasiocampidae	5
22.	Uraniidae	8
23.	Geometridae	65
24.	Notodontidae	17
25.	Erebidae	128
26.	Euteliidae	4
27.	Nolidae	9
28.	Noctuidae	35
	Total	418

Table 3: Summary of Moth Fauna by Site

Locations	Number of Nights when Light Traps were operated	No. of Species (No. of families)	Number of New Records	Number of Endemic Species	Number of Range Extensions
Mahabaleshwar	2	8 (4)	0	1	2
Matheran	2	12 (4)	0	1	1
Phansad WS	4	30 (11)	1	0	5
Amboli	4	83 (10)	3	1	27
Koyna WS	4	126 (14)	4	3	35
Bheemashankar WS	8	211 (16)	1	4	39
Sanjay Gandhi NP	48	226 (26)	1	14	70
Malshej Ghat	12	239 (15)	4	16	89

Table 4: Status and Distribution of Moths Recorded from northern Western Ghats

No.	Taxa	Distribution	Collection Sites	Range Notes
I	**HEPIALOIDEA**			
	(i) Hepialidae, Subfamily Unassigned			
	1. *Phassus signifer* Walker, 1856	India (West Bengal, east to north-west Himalaya), Nepal, Bangladesh, Myanmar, Myanmar, Indonesia, Malaysia	SGNP, MG	RE
II	**INCURVARIOIDEA**			
	(ii) Adelidae, Adelinae			
	2. *Adela* sp.	DD	SGNP	DD
III	**TINEOIDEA**			
	(iii) Tineidae			
	3. *Edosa* sp.	DD	SGNP	DD
IV	**GELECHIOIDEA**			
	(iv) Oecophoridae			
	4. *Tonica niviferana* (Walker, 1864)	India, Sri Lanka, Vietnam, China	SGNP, PWS	—
	Stathmopodinae			
	5. *Stathmopoda* sp.	DD	BWS	DD
	(v) Gelechiidae, Dichomeridinae			
	6. *Dichomeris* sp.	DD	BWS	DD
	(vi) Gracillariidae			
	7. *Caloptilia* sp.	DD	SGNP	DD
	(vii) Lecithoceridae			
	8. *Lecithocera* sp.	DD	SGNP	DD
V	**SESIOIDEA**			
	(viii) Sesiidae, Paranthreninae			
	9. *Paranthrene* sp.	DD	SGNP	DD
VI	**COSSOIDEA**			
	(ix) Cossidae, Cossinae			
	10. *Xyleutes persona* (Le Guillou, 1841)	India (Himachal Pradesh, Sikkim, West Bengal), Sri Lanka, Indonesia, China, Malaysia, New Guinea	MG, BWS	RE
	Zeuzerinae			
	11. *Zeuzera indica* Herrich-Schäffer, 1854	India (Sikkim, Himachal Pradesh), Bangladesh, Sri Lanka, Nepal, Myanmar, New Guinea, Australia	SGNP	RE
VII	**ZYGAENOIDEA**			
	(x) Limacodidae, Limacodinae			
	12. *Altha nivea* Walker, 1862	India (Sikkim, Jharkhand, southern India), Sri Lanka	MG	RE
	13. *Cania bilinea* Walker, 1859	India (Sikkim, Manipur, southern India), Vietnam, China, Malaysia, Indonesia	KWS	RE
	14. *Cania pulligonis* Swinhoe, 1889	India (Karnataka)	MG	EN, RE
	15. *Cania* sp.	DD	MG	DD
	16. *Cheromettia apicata* Moore, 1879	India (Sikkim, Manipur)	MG	EN, RE
	17. *Miresa nivaha* Moore, 1858/59	India (Karnataka, Kerala)	SGNP, MG	EN, RE
	18. *Narosa conspersa* Walker, 1855	India (Nagaland, southern India), Sri Lanka, Indonesia, Malaysia (Borneo)	MG	RE
	19. *Parasa bicolor* (Walker, 1855)	India, Myanmar to Malaya, Java, China, Taiwan	AM	–

Table 4: Status and Distribution of Moths Recorded from northern Western Ghats (*contd.*)

No.	Taxa	Distribution	Collection Sites	Range Notes
	20. *Parasa dharma* Moore, 1859	India (Sikkim), Myanmar, Indonesia	SGNP	RE
	21. *Parasa herbifera* (Walker, 1855)	India (Himachal Pradesh, Meghalaya, Tamil Nadu), Nepal	SGNP, BWS	RE
	22. *Parasa lepida* (Cramer, 1799)	Throughout India and Sri Lanka	KWS, SGNP, BWS	–
	23. *Parasa pastoralis* Butler, 1880	India (Sikkim), Pakistan, Nepal, Bhutan, China, Vietnam, Indonesia	MG	RE
	24. *Parasa* c.f. *dharma*	DD	SGNP	DD
	25. *Phlossa* sp.	DD	PWS	DD
	26. *Phocoderma* sp.	DD	KWS, SGNP, BWS, PWS	DD
	27. *Scopelodes* sp.	DD	MG	DD
	28. *Scopelodes venosa* Walker, 1855	India (Sikkim, Uttarakhand), Sri Lanka, Bangladesh, Myanmar	SGNP	RE
	29. *Thosea grandis* Hering, 1931	India (Meghalaya, Sikkim), China, Myanmar, Malaysia	MG, AM	RE
	30. *Thosea* sp.	DD	MG	DD
	(xi) **Zygaenidae, Chalcosiinae**		MG	DD
	31. *Eterusia aedea* (Clerck, 1759)	India (Sikkim, Assam, Meghalaya, Nagaland), China, Nepal, Bangladesh, Sri Lanka, Thailand, Japan	SGNP, MG, AM	RE
	32. *Artona* sp.	DD	SGNP	DD
VIII	**TORTRICOIDEA:**			
	(xii) **Tortricidae, Tortricinae**			
	33. *Archips* c.f. *machlopis*	DD	SGNP	DD
IX	**PYRALOIDEA:**			
	(xiii) **Crambidae**			
	Spilomelinae			
	34. *Aetholix flavibasalis* (Guenée, 1854)	India (Maharashtra, Gujarat, Andaman Is.), Sri Lanka, Myanmar, China, Indonesia, Malaysia (Borneo), Australia, Hawaii Is., Africa	KWS, SGNP, BWS	–
	35. *Aetholix* sp.	DD	BWS	DD
	36. *Agathodes ostentalis* (Geyer, 1837)	India (Uttarakhand, Sikkim, Khasi Hills, Nagaland), Sri Lanka, Myanmar, Indonesia	SGNP, MG, BWS, KWS	–
	37. *Agrotera scissalis* (Walker, 1866)	India (Sikkim, Meghalaya, Nagaland), Sri Lanka, Myanmar, Indonesia	KWS	RE
	38. *Arthroschista hilaralis* (Walker, 1859)	India (N.W. and E. Himalayas), Sri Lanka, Myanmar, Indonesia, Malaysia (Borneo), Australia	SGNP	RE
	39. *Botyodes asialis* Guenée, 1854	India, Pakistan (Baluchistan), Sri Lanka, Myanmar, Nepal, China, Indonesia and Malaysia (Borneo), Thailand, Vietnam, Singapore, Philippines, New Guinea, Australia, Africa	SGNP, MG, BWS, KWS, AM	–
	40. *Cnaphalocrocis poeyalis* (Boisduval, 1833)	India, Sri Lanka, Myanmar, Thailand, China, Japan, Indonesia, Australia, Africa, Mauritius, La Réunion	KWS	–
	41. *Conogethes punctiferalis* (Guenée, 1854)	India, China, Thailand, Australia	KWS	–
	42 *Cydalima laticostalis* (Guenée, 1854)	India (Andaman Is.), Sri Lanka, China, Myanmar, Thailand	SGNP, MG, BWS, KWS	RE
	43. *Daulia affralis* Walker 1859	India (Tamil Nadu), Bhutan, Myanmar, China, Indonesia, Malaysia (Borneo)	KWS, SGNP, AM	DD
	44. *Diaphania indica* (Saunders, 1851)	India, Nepal, China, Indo-Australia, Japan, Korea. Saudi Arabia, Central America, Africa, Madagascar	SGNP, BWS, KWS	–
	45. *Dichocrocis nilusalis* Walker, 1859	India, Sri Lanka, Indonesia, Malaysia (Borneo)	MG, KWS	–

Table 4: Status and Distribution of Moths Recorded from northern Western Ghats (*contd.*)

No.	Taxa	Distribution	Collection Sites	Range Notes
46.	*Filodes fulvidorsalis* Hubner, 1832	India (Sikkim), Sri Lanka, China, Vietnam, Indonesia	MG, AM	RE
47.	*Glyphodes bicolor* (Swainson, 1821)	Africa, India (Sikkim), Sri Lanka, Nepal, China, Myanmar, Thailand, Vietnam, Philippines, Japan, Australia	KWS	RE
48.	*Glyphodes bivitralis* Guenée, 1854	India (Uttarakhand, Sikkim, Assam, western and southern India, Andaman Is.), Sri Lanka, Myanmar, China, Indonesia, Malaysia (Borneo), Thailand, Singapore, Philippines, Australia, America	SGNP, MG, KWS	RE
49.	*Glyphodes* c.f. *actorionalis*	DD	KWS	RE
50.	*Glyphodes caesalis* Walker, 1859	India (Sikkim), Sri Lanka, Nepal, Myanmar, Thailand, Vietnam, Malaya, China, Singapore, Indonesia, Philippines	SGNP	RE
51.	*Glyphodes stolalis* Guenée, 1854	India (Sikkim, Assam), Sri Lanka, Nepal, China, Myanmar, Thailand, Vietnam, Indonesia, Malaysia (Borneo), Philippines, New Guinea, Australia, Papua New Guinea, Fiji	MG, SGNP	RE
52.	*Haritalodes derogata* (Fabricius, 1775)	India (Andaman & Nicobar Is.), Nepal, Malaysia, Singapore, Indonesia (Bali) China, Japan, New Guinea, Australia, Papua New Guinea, Samoa, Fiji, West Africa.	SGNP	RE
53.	*Herpetogramma* c.f. *luctuosalis*	DD	SGNP, KWS, AM	RE
54.	*Lamprosema commixta* Butler, 1879	India (Assam), Sri Lanka, Vietnam, Nepal, China, Indonesia, Japan	BWS	RE
55.	*Lygropia quaternalis* Zeller, 1852	India, Sri Lanka, Myanmar, China, W. Malaysia, Australia Africa	SGNP	–
56.	*Maruca vitrata* (Fabricius, 1787)	India, Pakistan, Sri Lanka, Bangladesh, Japan, China (including Hong Kong), Taiwan, Cambodia, Laos, Myanmar, Thailand, Vietnam, Indonesia, Philippines, Malaysia, Singapore, Korea, Australia, Tasmania, New Guinea, New Caledonia, New Zealand, Melanesia, Micronesia, Polynesia, South and Central America, Africa, Arabia, Madagascar	SGNP, MG, KWS, AM	–
57.	*Nausinoe geometralis* (Guenée,1854)	India, Sri Lanka, Nepal, China, Taiwan, Myanmar, Indonesia, Philippines, Australia, Africa	KWS, AM	–
58.	*Omiodes analis* Snellen, 1880	India, China, Taiwan, Indonesia.	KWS	–
59.	*Omiodes diemenalis* (Guenée, 1854)	India (Andaman & Nicobar Is.), Sri Lanka, Thailand, Seychelles, Vietnam, Singapore, Nepal, China, Java, Indonesia, Malaysia (Borneo), Philippines, Fiji, Tonga, Australia, Vanuatu, Tahiti, South America, North Africa	KWS	RE
60.	*Pagyda salvalis* Walker, 1859	India (Sikkim), Sri Lanka, Myanmar, China, Thailand, Indonesia, Philippines, Japan, New Guinea, Australia	KWS	RE
61.	*Parotis marginata* (Hampson, 1893)	India (Sikkim, West Bengal, Nicobar Is.), Sri Lanka, Papua New Guinea	KWS, AM	RE
62.	*Pleuroptya iopasalis* (Walker, 1859)	India, Sri Lanka, China, Indonesia, Malaysia (Borneo), Philippines.	KWS	–
63.	*Pycnarmon* c.f. *alboflavalis*	DD	KWS	DD
64.	*Pygospila tyres* (Cramer, 1780)	India (Tamil Nadu), Sri Lanka, Myanmar, Nepal, China, Thailand, Vietnam, Indonesia and Malaysia (Borneo), Philippines, Japan, New Guinea, Australia, Africa	SGNP, MG, BWS, KWS, AM	RE
65.	*Sameodes cancellalis* (Zeller, 1852)	India, Sri Lanka, Nepal, Myanmar, Thailand, Indo-china, China, Indonesia, Australia, America	KWS	–
66.	*Spoladea recurvalis* (Fabricius, 1775)	India, Sri Lanka, Nepal, China, Myanmar, Thailand, Malaysia, Australia, North and South America, Africa, southern Europe	SGNP, MG, KWS, AM	–
67.	*Terastia egialealis* Walker, 1859	India, Nepal, China, Thailand, Malaysia	SGNP, MG, KWS, AM	–
68.	*Tyspanodes* c.f. *linealis*	DD	SGNP	DD
Pyraustinae				
69.	*Hyalobathra* sp.	DD	KWS	–

Table 4: Status and Distribution of Moths Recorded from northern Western Ghats (*contd.*)

No.	Taxa	Distribution	Collection Sites	Range Notes
	Crambinae			
	70. *Chilo suppressalis* (Walker, 1863)	India (Punjab, Assam, Kolkata), Sri Lanka, China, Taiwan, Korea, Japan, Malaysia, Hawaii, Spain	SGNP	RE
	71. *Glaucocharis* sp. 1	DD	BWS	DD
	72. *Glaucocharis* sp. 2	DD	SGNP	DD
	Acentropinae [= Nymphulinae]			
	73. *Eristena* c.f. *postalbalis*	DD	KWS	DD
	74. *Paracymoriza vagalis* (Walker, 1865)	India (Punjab, Tamil Nadu), Sri Lanka, Nepal, China, Myanmar, Thailand, Indonesia, Malaysia (Borneo)	KWS	RE
	75. *Parapoynx diminutalis* Snellen, 1880	Europe, Africa, India (Punjab, Maharashtra), Sri Lanka, China, Indonesia, North America	SGNP	–
	(xiv) **Pyralidae**			
	Pyralinae			
	76. *Bostra indicator* Walker, 1863	Nepal, China, Japan	KWS	NR
	77. *Ocrasa* sp.	DD	KWS	–
	78. *Tamraca torridalis* (Lederer, 1863)	India (N.W. Himalayas Nagaland, Maharashtra, Gujarat, Karnataka), Sri Lanka, Myanmar, Java, Indonesia, China	KWS	–
	79. *Vitessa suradeva* Moore, 1860	India (Sikkim, Assam, hills of southern India, Andaman Is.), Sri Lanka, Myanmar, Indonesia, Malaysia (Borneo)	AM	RE
	80. *Zitha tactilis* Swinhoe, 1890	India (Sikkim, Tamil Nadu), Myanmar	KWS	RE
	Epipaschiinae			
	81. *Salma* sp.	DD	SGNP	DD
X	**THYRIDOIDEA**			
	(xv) **Thyrididae, Striglininae**			
	82. *Banisia myrsusalis* (Walker, 1859)	India, Australia, North and South America, Brazil	SGNP	—
	83. *Collinsa* sp.	DD	SGNP	DD
	84. *Striglina scitaria* (Walker, 1862)	India, Sri Lanka, Myanmar, Indonesia, Malaysia (Borneo), Taiwan, Japan, New Guinea, Australia, Papua New Guinea, Fiji	KWS, SGNP, PWS	—
	85. *Striglina* sp. 1	DD	BWS	DD
	86. *Striglina* sp. 2	DD	BWS	DD
	87. *Striglina* sp. 3	DD	PWS	DD
XI	**PTEROPHOROIDEA**			
	(xvi) **Pterophoridae**			
	88. *Emmelina* sp.	DD	SGNP, KWS	DD
	89. *Megalorrhipida* sp.	DD	PWS	DD
	90. *Hellinsia* sp.	DD	SGNP	DD
XII	**BOMBYCOIDEA**			
	(xvii) **Sphingidae**			
	Smerinthinae, Smerinthini			
	91. *Marumba spectabilis* (Butler, 1875)	India (eastern & western Himalaya northern India, Maharashtra, Uttarakhand, West Bengal, Meghalaya), Nepal, China, Thailand, Laos, Vietnam, Malaysia, Indonesia	SGNP, MG	–

Table 4: Status and Distribution of Moths Recorded from northern Western Ghats (*contd.*)

No.	Taxa	Distribution	Collection Sites	Range Notes
92.	*Marumba dyras* (Walker, 1856)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Karnataka, Gujarat, Maharashtra, Andaman & Nicobar islands), Sri Lanka, Nepal, Bhutan, Bangladesh, Myanmar, Thailand, S. China, Philippines, Indonesia, Malaysia (Borneo), Taiwan	SGNP, MG, BWS, KWS	–
93.	*Marumba poliotis* Hampson, 1907	India (Maharashtra, southern India)	SGNP, MG, BWS	EN
94.	*Marumba indicus* (Walker, 1856)	India (Maharashtra, Karnataka), Sri Lanka	SGNP, MG, BWS, KWS	–
95.	*Marumba nympha* Rothschild & Jordan, 1903	India (Maharashtra, southern India)	MB	EN, RE
96.	*Sataspes tagalica* f. *hauxwelli*	India, Myanmar, China	SGNP	–
97.	*Leucophlebia lineata* Westwood, 1847	India, Sri Lanka, Nepal, Thailand, Cambodia, Vietnam, Malaysia, Indonesia, Philippines, China, Taiwan	MG	RE
98.	*Clanis phalaris* (Cramer, 1777)	India (Sikkim, Assam, Arunachal Pradesh, Nagaland, Manipur, Meghalaya, Mizoram, Maharashtra, Karnataka, Uttarakhand, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Pondicherry, Andaman & Nicobar Is.), Sri Lanka, Myanmar	SGNP, MG	–
99.	*Polyptychus dentatus* (Cramer, 1777)	Pakistan, India (Uttarakhand, Sikkim, West Bengal, Maharashtra), Sri Lanka, Bhutan	SGNP	–
Smerinthinae, Ambulycini				
100.	*Amplypterus panopus* (Cramer, 1779)	India, Sri Lanka, Myanmar, China, Malaysia, Philippines, Indonesia	AM	–
101.	*Ambulyx substrigilis* (Jordan, 1923)	India (southern India)	BWS, MG	EN, RE
Sphinginae, Sphingini				
102.	*Psilogramma menephron* (Cramer, 1780)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Gujarat, Andaman Is.), Sri Lanka, Nepal, China, Myanmar, Thailand, Vietnam, Indonesia, Philippines, Australia	SGNP, MG, BWS	RE
103.	*Psilogramma increta* (*Walker*, [*1865*])	India (Jammu & Kashmir, Uttarakhand, Maharashtra), Sri Lanka, Myanmar, Nepal, China, Thailand, Vietnam, Malaysia, Korea, Taiwan, Japan	SGNP, MG	–
104.	*Agnosia orneus* (Westwood, 1847)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Madhya Pradesh, Uttar Pradesh, Bihar, Chattisgarh, Rajasthan, Gujarat, Maharashtra, Goa, Tamil Nadu, Karnataka, Andhra Pradesh), Sri Lanka	SGNP, MG, KWS	–
105.	*Agnosia microta* (Hampson, 1907)	India (Madhya Pradesh, Uttar Pradesh, Bihar, Chattisgarh, Rajasthan, Jharkhand, Gujarat, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh), Sri Lanka	SGNP, KWS	–
Sphinginae, Acherontini				
106.	*Agrius convolvuli* (Linnaeus, 1758)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Maharashtra, Gujarat, Andaman Is.), Pakistan, Sri Lanka, Myanmar, China, Malaysia, Indonesia, Mongolia, Siberia, Japan, Africa, Australia, the Pacific and Southern Europe	SGNP, MG, BWS, KWS, MB, MN	–
107.	*Acherontia lachesis* Fabricius, 1798	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Maharashtra, Gujarat, Goa, Tamil Nadu, Karnataka, Andhra Pradesh, Andaman Is.), Sri Lanka, Pakistan, Nepal, Myanmar, Malaysia, Indonesia, China, Japan, Philippines, Hawaii Is., Russia	SGNP, MG, BWS, KWS, MB, MN	–

Table 4: Status and Distribution of Moths Recorded from Northern-western Ghats (*contd.*)

No.	Taxa	Distribution	Collection Sites	Range Notes
108.	*Acherontia styx* (Westwood,1848)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Maharashtra, Gujarat, Andaman Is), Sri Lanka, Pakistan, China, Nepal, Myanmar, Bangladesh, Indonesia, Saudi Arabia, Iraq, Iran	SGNP, MG, BWS, KWS	–
109.	*Dolbina inexacta* (Walker,1856)	India (W.& E. Himalaya, Tamil Nadu, Karnataka, Andhra Pradesh), China, Malaysia, Bhutan, Thailand, Vietnam	SGNP, MG, BWS	RE
110.	*Meganoton rubescens* (Butler, 1876)	India (Sikkim, Andaman Is.), Thailand, Indonesia, Malaysia (Borneo), Philippines, Australia	SGNP, MG, BWS, MN	RE
Macroglossinae, Dilophonotini				
111.	*Cephonodes* sp.	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Maharashtra, Goa, Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka), Africa, Sri Lanka, Bhutan, Nepal, East Asia, South-East Asia, Australia	SGNP, PWS	–
Macroglossinae, Macroglossini, Macroglossina				–
112.	*Neogureica hyas* (Walker, 1856)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Madhya Pradesh, Madhya Pradesh, Uttar Pradesh, Chattisgarh, Rajasthan, Maharashtra, Goa, Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka), Nepal, Bhutan, Myanmar, Bangladesh, Thailand, Vietnam, Japan, Malaysia, Indonesia (Sumatra, Java), Philippines	SGNP, MG	–
113.	*Nephele hespera* (Fabricius, 1775)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Pondicherry, Karnataka, Gujarat, Maharashtra, Andaman & Nicobar Is.), Sri Lanka, Pakistan, Bhutan, Nepal, China, Thailand, Vietnam, Malaysia, Indonesia	SGNP, MG, MN, BWS, KWS	–
114.	*Daphnis nerii* (Linnaeus, 1758)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Maharashtra, Gujarat), Sri Lanka, Pakistan, Bhutan, Myanmar, Thailand, China, Taiwan, Japan, Malaysia, Europe, Yemen, Africa, Mauritius, Saudi Arabia, Afghanistan	SGNP	–
115.	*Acosmeryx shervillii* Boisduval, 1875	India (Sikkim, northern India, Maharashtra, southern India), Sri Lanka, Nepal, China, Bhutan, Thailand, Vietnam, Malaysia, Indonesia	SGNP, MG, KWS	–
116.	*Acosmeryx pseudonaga* Boisduval, 1875	India, Malaysia, Philippines	MG	–
117.	*Macroglossum gyrans* Walker, 1856	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Madhya Pradesh, Karnataka, Tamil Nadu, Gujarat, Maharashtra), Sri Lanka, Pakistan, Bhutan, Myanmar, Thailand	SGNP, MG	–
118.	*Macroglossum particolor* Rothschild & Jordan, 1903	India (Maharashtra, southern India), Sri Lanka, Maldive Islands	SGNP	–
119.	*Macroglossum belis* (Linnaeus, 1758)	Pakistan, India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, West Bengal, Madhya Pradesh, Karnataka, Gujarat, Maharashtra), Sri Lanka, Nepal, China, Bhutan, Thailand, Vietnam, Indonesia, Taiwan, Japan	SGNP	–
120.	*Macroglossum corythus* Walker, 1856	India (Eastern Himalaya, southern India, Andaman Islands), China	MG	RE
121.	*Macroglossum sitiene* Walker, 1856	India (Eastern Himalaya, southern India.), Sri Lanka, China, Bangladesh, Myanmar, Thailand, Vietnam, Malaysia, Indonesia, Philippines, Taiwan, Japan	SGNP	–

Table 4: Status and Distribution of Moths Recorded from Northern-western Ghats (*contd.*)

No.	Taxa	Distribution	Collection Sites	Range Notes
	Macroglossinae, Macroglossini, Choerocampina			–
122.	*Hippotion rosetta* (Swinhoe, 1892)	India (Maharashtra, Goa, Karnataka, Tamil Nadu, Andhra Pradesh, Gujarat, Orissa, Sikkim, West Bengal, Bihar, Uttar Pradesh, Uttarakhand, Himachal Pradesh, Haryana, Assam, Arunachal Pradesh, Meghalaya, Lakshadweep Islands, Andaman & Nicobar Is.), Sri Lanka, Pakistan, Thailand, southern China and Taiwan to southern Japan (Ryukyu Archipelago), Philippines, eastern Indonesia, Papua New Guinea	SGNP, MG	–
123.	*Hippotion celerio* (Linnaeus, 1758)	India (Western and Eastern Himalaya, southern India) and throughout the world except in the far North, New Zealand	SGNP, MG, BWS	RE
124.	*Hippotion rafflesii* (Moore, 1858)	India (Eastern Himalaya, southern India), Sri Lanka, China, Myanmar, Indonesia, Malaysia (Borneo), Taiwan	MG, KWS	RE
125.	*Pergesa acteus* (Cramer, 1779)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, West Bengal, Maharashtra, Karnataka, Andaman Is.), Sri Lanka, Nepal, China, Myanmar, Thailand, China, Taiwan, Japan, Malaysia, Singapore, Indonesia, Philippines	SGNP, MG	–
126.	*Hyles livornica* (Fabricius, 1775)	India (Western Himalaya and southern India), Pakistan, China, Europe, Africa	SGNP, MG	RE
127.	*Theretra nessus* (Drury, 1773).	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Gujarat, Maharashtra, Goa, Andhra Pradesh, Karnataka, Tamil Nadu, Andaman Is.), Sri Lanka, Nepal, China, Bhutan, Myanmar, Thailand	SGNP, MG, BWS, KWS	–
128.	*Theretra boisduvalii* (Bugnion, 1839)	India (eastern Himalaya, Maharashtra, Gujarat, Uttarakhand, Meghalaya, Sikkim), Sri Lanka, China, Thailand, Malaysia, Indonesia, Vietnam, Taiwan, Turkey, Iran	SGNP, MG, BWS	–
129.	*Theretra gnoma* (Fabricius, 1775)	India (southern India), Sri Lanka	SGNP, MG, BWS, KWS	RE
130.	*Theretra clotho* (Drury, 1773)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, West Bengal, Gujarat, Maharashtra, Karnataka, Tamil Nadu, Andaman Is.), Sri Lanka, Nepal, China, Myanmar, Indonesia	SGNP, MG, BWS, KWS, MN, AM	–
131.	*Theretra alecto* (Linnaeus, 1758)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram), Pakistan, Iraq, Iran, Afghanistan, Uzbekistan, Kyrgyzstan, Greece, Bulgaria, Egypt, Lebanon, Israel, Turkey, Turkmenistan	SGNP, MG	–
132.	*Theretra lycetus* (*Cramer 1775*)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, West Bengal, Gujarat, Maharashtra, Karnataka), Sri Lanka, Bhutan, Myanmar, Indonesia	SGNP, MG, BWS, KWS	–
133.	*Theretra oldenlandiae* (Fabricius, 1775)	India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Madhya Pradesh, Gujarat, Maharashtra, Karnataka), Sri Lanka, Nepal, China, Bhutan, Myanmar, Malaysia, Indonesia, Philippines	SGNP, MG, BWS, KWS	–
134.	*Theretra silhetensis* (Walker, 1856)	India (eastern Himalayas, southern India, Andaman Is.), Sri Lanka, Nepal, China, Bangladesh, Thailand, Vietnam, Malaysia, Indonesia, Taiwan, Japan, Australia	MG	RE
135.	*Theretra castanea* (Moore, 1872)	India (Maharashtra, Karnataka, Kerala, Tamil Nadu)	SGNP, MG	EN

Table 4: Status and Distribution of Moths Recorded from Northern-western Ghats

No.	Taxa	Distribution	Collection Sites	Range Notes
	(xviii) **Bombycidae, Bombycinae**			
	136. *Ocinara* sp.	DD	SGNP	DD
	137. *Trilocha* c.f. *varians*	DD	SGNP	DD
	138. *Trilocha* c.f. *friedeli*	DD	SGNP	DD
	(xix) **Eupterotidae, Eupterotinae**			
	139. *Eupterote lineosa* (Walker, 1855)	India (Sikkim, Nagaland), Bangladesh, Bhutan	SGNP, MG, BWS, AM, PWS	RE
	140. *Eupterote murina* (Moore, 1877)	Sri Lanka	BWS, PWS NR,	RE
	141. *Eupterote* sp.	DD	MG	DD
	Subfamily Unassigned			
	142. *Ganisa similis* Moore, 1884	India (Himachal Pradesh, Sikkim, Uttarakhand, Nagaland), Sri Lanka, China, Bangladesh, Malaysia	SGNP, AM	RE
	(xx) **Saturniidae, Saturniinae**			
	143. *Actias selene* (Hübner, 1806)	India (Kashmir, Sikkim, Assam, Meghalaya, Manipur, West Bengal, Bihar, Orissa, Himachal Pradesh, Uttarakhand, Gujarat, Maharashtra, Karnataka, Tamil Nadu), Sri Lanka, Nepal, China, Bhutan, Bangladesh, Myanmar, Indonesia, Philippines, Afghanistan, Russia, Malaysia	SGNP, MG, BWS, MN, AM, MB	–
	144. *Attacus taprobanis* Moore, 1882-1883	India (Maharashtra, Karnataka, Kerala, Tamil Nadu, Gujarat), Sri Lanka	SGNP, MG, BWS, KWS	–
	145. *Antheraea paphia* (Linnaeus, 1758)	India (Kashmir, Sikkim, Assam, Meghalaya, West Bengal, Bihar, Orissa, Himachal Pradesh, Uttarakhand, Madhya Pradesh, Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Tamil Nadu), Sri Lanka, Nepal, Bhutan, Bangladesh, Myanmar, Pakistan	SGNP, MG, BWS, KWS, MB	–
	147. *Loepa schintlmeisteri* Brechlin, 2000	India (Himalaya, Maharashtra), Myanmar, Thailand, Malaysia, Indonesia	MG, BWS	–
XIII	**LASIOCAMPOIDEA**			
	(xxi) **Lasiocampidae, Lasiocampinae**			
	148. *Trabala vishnou* (Lefèbvre, 1827)	India (Uttarakhand, West Bengal, Andaman Is.), Sri Lanka, China, Bhutan, Bangladesh, Myanmar, Indonesia, Japan	SGNP, MG, BWS	RE
	149. *Arguda flavovittata* Moore, 1879	India (Himachal Pradesh, Uttarakhand), Bhutan	SGNP	RE
	150. *Lebeda nobilis* Walker, 1855	India (Nagaland, West Bengal, east to north-west Himalaya), Nepal, Bangladesh	MG, KWS, BWS	RE
	151. *Metanastria aconyta* (Cramer, 1777)	India (Karnataka, Kerala, Sikkim), Bangladesh	PWS	RE
	152. *Streblote siva* (Lefèbvre, 1827)	India (West Bengal, southern India, north-west Himalaya), Myanmar, Iraq, Pakistan	SGNP	RE
XIV	**GEOMETROIDEA**			
	(xxii) **Uraniidae**			
	Microniinae			
	153. *Micronia aculeata* Guenée, 1857	India, Sri Lanka, Myanmar, China, Taiwan	SGNP, MG, BWS, KWS, AM	–
	Epipleminae			
	154. *Orudiza protheclaria* Walker, 1861	India (Sikkim, Uttarakhand, Meghalaya, Maharashtra, Karnataka, Kerala), Myanmar, Bangladesh, Thailand, Cambodia, Indonesia	SGNP, MG, BWS	–
	155. *Monobolodes* sp.	DD	SGNP, MG	DD
	156. *Phazaca leucocera* Hampson, 1891	India (Uttarakhand, southern India), Sri Lanka, Indonesia, Malaysia (Borneo), Papua New Guinea	SGNP, MG, BWS, KWS	RE

Table 4: Status and Distribution of Moths Recorded from Northern-western Ghats

No.	Taxa	Distribution	Collection Sites	Range Notes
157.	*Phazaca* sp.		BWS	DD
158.	*Phazaca* c.f. *theclata*	DD	SGNP	–
	Auzeinae			
159.	*Decetia numicusaria* (Walker, 1860)	India, Bangladesh.	SGNP	–
160.	*Decetia subobscurata* Walker, 1862	India (North India, Tamil Nadu, Kerala), Sri Lanka	MG	RE
	(xxiii) **Geometridae**			
	Ennominae, Hypochrosini			
161.	*Hypochrosis hyadaria* Guenée, 1858	India (Sikkim, Uttarakhand, Khasi Hills, Tamil Nadu), Sri Lanka	KWS	RE
162.	*Achrosis incitata* (Walker, 1862)	India, Nepal, China	SGNP	–
	Ennominae, Plutodini			
163.	*Plutodes transmutata* Walker, 1861	India (Himachal Pradesh, Uttarakhand), Nepal	BWS	RE
164.	*Caberini medardaria* Herrich-Schäffer, 1856	India, Sri Lanka, Nepal, Myanmar, Bangladesh, Australia	SGNP	–
	Ennominae, Caberini			
165.	*Hyperythra lutea* (Stoll, 1787)	India, Sri Lanka, Myanmar, China, Indonesia, New Guinea	SGNP	–
	Ennominae, Abraxini			
166.	*Abraxas* sp.	DD	MG	DD
167.	*Gonodontis* c.f. *clelia*	DD	SGNP	DD
	Ennominae, Cassymini			
168.	*Heterostegane* sp.	DD	MG	DD
	Ennominae, Eutoeini			
169.	*Eutoea heteroneurata* (Guenée, 1857)	India, Australia, New Britain	MG	–
170.	*Luxiaria* sp.	DD	SGNP	DD
	Ennominae, Macariini			
171.	*Chiasmia frugaliata* (Guenée, 1858)	India (Maharashtra, Chennai, Uttarakhand), Pakistan, Sri Lanka	SGNP, MG	–
172.	*Chiasmia inchoata* (Walker, 1861)	India (Maharashtra, north India)	SGNP, MG	EN
173.	*Chiasmia eleonora* (Cramer, 1780)	India (North India, Uttarakhand), Malaysia	SGNP, MG, AM	–
174.	*Godenela* sp.	DD	MG, AM	DD
175.	*Chiasmia emersaria* (Walker, 1861)	India, Nepal, China, Thailand, Japan	BWS	–
176.	*Chiasmia* c.f. *triangulata*	DD	SGNP	DD
	Ennominae, Boarmiini			
177.	*Hyposidra talaca* (Walker, 1860)	India (N.E. Himalaya, Uttarakhand, Andaman & Nicobar Is.), China, Australia	SGNP, MG, BWS, AM	RE
178.	*Dasyboarmia* c.f. *subpilosa*	DD	KWS, BWS	DD
179.	*Krananda* sp.	DD	MG	DD
180.	*Alcis* sp.	DD	PWS	DD
181.	*Amblychia hymenaria* (Guenée, 1857)	India (Central India, Sikkim, Assam, Meghalaya, Uttarakhand, Chhattisgarh), Nepal, Bangladesh, Malaysia, Indonesia	SGNP, MG	RE
182.	*Biston* sp.	DD	DD	DD
183.	*Cleora injectaria* (Walker, 1860)	Japan, Indo-Australian Tropics to Fiji and New Caledonia	SGNP, BWS	—
184.	*Cleora* sp. 1	DD	MG	DD
185.	*Cleora* sp. 2	DD	MG	DD
186.	*Cleora* sp. 3	DD	MG	DD
187.	*Cleora* sp. 4	DD	SGNP	DD
188.	*Cleora* sp. 5	DD	SGNP	DD
189.	*Cleora* sp. 6	DD	SGNP	DD

Table 4: Status and Distribution of Moths Recorded from Northern-western Ghats

No.	Taxa	Distribution	Collection Sites	Range Notes
190.	*Cleora* sp. 7	DD	SGNP	DD
191.	*Cleora* sp. 8	DD	SGNP	DD
192.	*Ectropis* sp. 1	DD	MG	DD
193.	*Ectropis* sp. 2	DD	MG	DD
194.	*Ruttellerona cessaria* (Walker, 1860)	India (southern India), Sri Lanka	MG	RE
195.	*Aplochlora* c.f. *viviiaca*	DD	SGNP	DD
Geometrinae, Dysphaniini				
196.	*Dysphania percota* (Swinhoe, 1891)	India (Maharashtra, Goa, Karnataka, Tamil Nadu)	SGNP, MN, BWS, MG	EN, RE
Geometrinae, Pseudoterpnini				
197.	*Pingasa* sp.	DD	BWS, AM	DD
198.	*Herochroma* sp.	DD	KWS	DD
199.	*Herochroma* c.f. *orientalis*	DD	KWS	DD
Geometrinae, Geometrini				
200.	*Agathia angustilimes* Prout, 1926	India (Delhi)	SGNP, MG	EN, RE
201.	*Agathia eromena* Prout, 1916	India	BWS	EN
202.	*Agathia laetata* (Fabricius, 1794)	India, Sri Lanka, Nepal, Bhutan, Bangladesh, Malaysia, Taiwan	AM	–
203.	*Pelagodes falsaria* Prout, 1912	India, Indonesia, Malaysia (Borneo)	MG	–
204.	*Agathia* c.f. *lycaenaria*	DD	BWS	DD
205.	*Comostola* c.f. *chlorargyra*	DD	SGNP	DD
Geometrinae, Comibaenini				
206.	*Comibaena cassidara* (Guenée, 1857)	India, China, Thailand, Singapore, Indonesia, Malaysia (Borneo)	SGNP	–
207.	*Maxates* sp.	DD	MN	DD
208.	*Hemithea tritonaria* (Walker, 1863)	India, Sri Lanka, Nepal, China, Korea, Japan, Ryuku Is., Malaysia, Indonesia, Philippines	MG	–
209.	*Thalassodes quadraria* Guenée, 1857	India, Africa, China	MG	–
210.	*Thalassodes* sp.	DD	SGNP	DD
Sterrhinae				
211.	*Antitrygodes cuneilinea* (Walker, 1863)	India	SGNP	EN
212.	*Chrysocraspeda olearia* (Guenée, 1858)	India, China	MB	–
213.	*Chrysocraspeda* sp.	DD	KWS	DD
214.	*Problepsis vulgaris* Butler, 1889	India (Himachal Pradesh, Uttarakhand, West Bengal, Southern Peninsula), Sri Lanka, Nepal, China	SGNP, BWS, AM	RE
215.	*Scopula* sp.	DD	KWS, AM	DD
216.	*Scopula* c.f. *emissaria*	DD	SGNP	DD
217.	*Scopula* c.f. *pulchellata*	DD	BWS	DD
218.	*Timandra convectaria* Walker, 1861	China, Bangladesh, Indonesia, Japan, Korea	KWS	NR
219.	*Traminda mundissima* (Walker, 1861)	India (Uttarakhand, southern India)	SGNP	EN, RE
220.	*Zythos* c.f. *obliterata*	DD	SGNP	DD
Larentiinae				
221.	Eupithecia sp. 1	DD	SGNP	DD
222.	Eupithecia sp. 2	DD	MG	DD
Desmobathrinae, Desmobathrini				
223.	*Conolophia nigripuncta* (Hampson, 1891)	India (Uttarakhand, Nilgiri Hills), Myanmar, Indonesia, Malaysia (Borneo)	MG, BWS	RE

Table 4: Status and Distribution of Moths Recorded from Northern-western Ghats

No.	Taxa	Distribution	Collection Sites	Range Notes
	Desmobathrinae, Eumeleini			
	224. *Eumelea ludovicata* Guenée, 1857	South China, Guam, Papua New Guinea	MG, AM	NR
	225. *Oxymacaria* sp.	DD	MG	DD
XV	**NOCTUOIDEA:**			
	(xxiv) **Notodontidae**			
	Dudusinae			
	226. *Ambadra* sp.	DD	SGNP, KWS	DD
	227. *Hyperaeschrella* sp.	DD	MG	DD
	228. *Netria viridescens* Walker, 1855	India (Sikkim, Uttarakhand, Nagaland), Sri Lanka, China, Indonesia, New Guinea	SGNP	RE
	229. *Dudusa synopla* Swinhoe, 1907	India, China, Myanmar, Indonesia, Malaysia (Borneo), Taiwan	MG	RE
	230. *Bireta longivitta* Walker, 1856	India (Himachal Pradesh, Sikkim, Nagaland), Myanmar	MG	RE
	231. *Vaneeckeia pallidifascia* Hampson, 1892	India (N.E. Himalaya), China, Vietnam, Malaysia, Indonesia, Philippines, Japan, New Guinea	SGNP, MG	RE
	232. *Neocerura liturata* (Walker, 1855)	India (Sikkim, Uttarakhand, Assam, Maharashtra, Tamil Nadu), Sri Lanka, China	MG, SGNP	Nil
	Notodontinae			
	233. *Micromelalopha* sp.	DD	PWS	DD
	234. *Neodrymonia basalis* (Moore, 1879)	India (West Bengal, Sikkim), China	SGNP	RE
	235. *Cleapa latifascia* Walker 1855	Myanmar, Pakistan	SGNP	NR
	Phalerinae			
	236. *Phalera grotei* Moore, 1859	India (Sikkim, Nagaland, West Bengal, Himachal Pradesh, Uttarakhand, Maharashtra, Tamil Nadu), China, Vietnam, Indonesia and Malaysia (Borneo), Korea	SGNP, MG	–
	237. *Phalera sangana* Moore, 1859	India (north-east and north-west Himalaya), Bhutan, China	MG	RE
	238. *Quadricalcarifera viridimaculata* Matsumura, 1922	India (N.E. Himalaya), China, Taiwan, Sundaland, Philippines (Mindanao)	MG	RE
	239. *Syntypistis fasciata* (Moore, 1879)	India (Sikkim), China	SGNP, MG, PWS	RE
	240. *Syntypistis* sp.	DD	MG	DD
	Ceirinae			
	241. *Gargetta* sp.	DD	SGNP	DD
	Subfamily Unassigned			
	242. *Eupydna testacea* (Walker, 1856)	India (N.E. Himalaya), Indonesia and Malaysia (Borneo)	MG	RE
	(xxv) **Erebidae**			
	Lymantrinae, Lymantriini			
	243. *Lymantria mathura* (*Moore, 1865*)	India (N.W. Himalayas, Uttarakhand, Sikkim), Nepal, China, Korea, Japan	SGNP, MG	RE
	244. *Lymantria* sp.	DD	SGNP	DD
	Lymantrinae, Orgyiini			
	245. *Orgyia* sp.	DD	SGNP	DD
	Lymantrinae, Arctornithini			
	246. *Arctornis* sp.	DD	BWS	DD
	Lymantrinae, Nygmiini			
	247. *Euproctis* sp.	DD	KWS, PWS	DD
	248. *Somena* sp.	DD	PWS	DD
	249. *Nygmia* sp.	DD	PWS	DD
	250. *Nygmia* c.f. *madana*	DD	BWS	DD

Table 4: Status and Distribution of Moths Recorded from Northern-western Ghats

No.	Taxa	Distribution	Collection Sites	Range Notes
	Lymantrinae, tribe unassigned			
251.	*Cispia charma* Swinhoe, 1899	India (Karnataka)	BWS	EN, RE
	Arctiinae, Lithosiini			
252.	*Barsine striata* (Bremer *et* Grey, 1852)	India (N.W. Himalaya, Himachal Pradesh), China, Korea, Japan, Russia	BWS	RE
253.	*Brunia antica* (Walker, 1854)	India (Sikkim, Uttarakhand, Meghalaya, Nicobar Is), Sri Lanka, Chagos Is., China, Indonesia, Malaysia (Borneo)	SGP, MG, KWS, BWS	RE
254.	*Cyana ridleyi* Hampson, 1900	India (Northern India, Uttarakhand), Malaysia, Singapore, Indonesia, Malaysia (Borneo)	SGNP, MG	RE
255.	*Cyana* sp.	DD	SGNP	DD
256.	*Diduga* sp.	DD	KWS	DD
257.	*Eilema serva* (Walker, 1854)	India (Sikkim, West Bengal, Assam, Meghalaya, Nagaland), Nepal, Japan, Europe	SGNP, MG	RE
258.	*Lithosia* sp.	DD	SGNP	DD
259.	*Macrobrochis gigas* (Walker, 1854)	India (Sikkim, Uttarakhand, Assam), Nepal, China, Bhutan, Indonesia	SGNP, MG, KWS	RE
260.	*Nepita conferta* (Walker, 1854)	India (Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu, North India), Sri Lanka	SGNP, MG, KWS, PWS	–
261.	*Oeonistis entella* (*Cramer 1779*)	India (southern India), Sri Lanka	SGNP, MG, KWS, BWS	RE
	Arctiinae, Syntomini			
262.	*Amata bicincta* Kollar, 1844	India (Himachal Pradesh, Uttarakhand, Sikkim, Khasi Hills), China	SGNP, MG, BWS	RE
263.	*Amata cyssea* Stoll 1782	India (Himalayas, Uttarakhand, Sikkim), Sri Lanka	SGNP, MG	RE
264.	*Amata minor* Warren 1888	India (Punjab)	MG, BWS	EN, RE
265.	*Caeneressa* sp.	DD	BWS	DD
266.	*Nannoarctia dentata* (Walker, 1855)	India (southern India to eastern India)	SGNP, MG	EN, RE
	Arctiinae, Arctiini			
267.	*Amerila astreus* (Drury, 1773)	India (Sikkim, Uttarakhand, Arunachal Pradesh, West Bengal, Maharashtra, Tamil Nadu), Sri Lanka, China, Myanmar, Malaysia, Indonesia, Philippines, New Guinea	MG, KWS, AM	–
268.	*Argina argus* Kollar, 1844	India, Sri Lanka, Nepal, China, Bangladesh, Myanmar, Indonesia, Philippines, Japan, New Guinea, Australia, Oceania, Ghana, Madagascar, Seychelles	SGNP, MG, BWS, KWS, AM	RE
269.	*Creatonotos transiens* (Walker, 1855)	India (eastern India, Uttarakhand, Sikkim), Nepal, China, Malaysia, Indonesia, Philippines, Japan	SGNP, MG, BWS, KWS, AM	RE
270.	*Lemyra spilosomata* (Walker, 1864)	India (southern India)	SGNP, KWS, MG, BWS, AM	EN, RE
271.	*Spilosoma montanum* Guérin-Méneville, 1843	India (Punjab, Tamil Nadu).	SGNP, MG	EN, RE
272.	*Rajendra perrotteti* (Guérin-Méneville, 1844)	India (Punjab, Himachal Pradesh, Uttarakhand, West Bengal, Bihar, Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu)	SGNP, MG, BWS, AM, PWS	EN, RE
273.	*Rajendra* sp.	DD	BWS, AM	DD
274.	*Euchromia polymena* (Linnaeus, 1758)	India (Nagaland, Maharashtra, Karnataka, Gujarat, Andaman Is), Sri Lanka, China, Myanmar, Malaysia, Indonesia, Philippines, Australia	SGNP, PWS	–
275.	*Pericallia ricini* (Fabricius, 1775)	India, Sri Lanka	SGNP, MG, BWS, KWS, PWS	–
	Herminiinae			
276.	*Adrapsa ereboides* (Walker, 1864)	India, Sri Lanka, Myanmar, Singapore, Indonesia, Indonesia, Malaysia (Borneo)	SGNP, MG	–
277.	*Hydrillodes* c.f. *abavalis*	DD	KWS	DD

Table 4: Status and Distribution of Moths Recorded from Northern-western Ghats

No.	Taxa	Distribution	Collection Sites	Range Notes
	Aganainae			
278.	*Asota ficus* (Fabricius, 1775)	Pakistan, India (Uttarakhand, southern India), Sri Lanka, China, Nepal, Myanmar, Thailand, Malaysia, Japan	MG, BWS	RE
279.	*Asota caricae* (Fabricius, 1775)	India, Sri Lanka, China, Malaysia, Indonesia, Philippines, Australia	SGNP, MG	–
280.	*Asota sericea* (Moore, 1878)	India (southern India)	SGNP	EN, RE
281.	*Digama marchali* (Guérin, Méneville, 1843)	India (Maharashtra, Gujarat, southern India), Myanmar	SGNP, MG, BWS, PWS	–
	Hypeninae			
282.	*Dichromia pullata* Moore, 1885	Sri Lanka	MG, AM	NR
283.	*Naarda* sp.	DD	KWS	DD
	Scoliopteryginae			
284.	*Gonitis mesogona* (Walker, 1858)	India, Thailand, Vietnam, Indonesia, Indonesia, Malaysia (Borneo), Japan	PWS	–
285.	*Rusicada albitibia* (Walker, 1857-1858)	India, Sri Lanka, Myanmar, Japan, China, Indonesia, Australia, Papua New Guinea, Fiji, Samoa	SGNP	–
286.	*Rusicada combinans* (Walker, 1858)	India, Sri Lanka, Myanmar, China, Australia, Fiji, Africa	MG	–
287.	*Rusicada leucolopha* (Prout, 1928)	China, Japan, Sumatra	KWS	NR
288.	*Rusicada metaxantha* (*Walker*, 1858)	India, Sri Lanka, China, Myanmar, Indonesia, Japan, Australia, Solomon Is., Fiji, Samoa	MG, KWS	–
	Calpinae, Calpini			
289.	*Calyptra minuticornis* (Guenée, 1852)	India, Sri Lanka, China, Indonesia, Japan, Australia	MG, KWS	–
290.	*Eudocima salaminia* Walker, 1857	India, China, Philippines, Japan, New Guinea.	MG, SGNP, AM	–
291.	*Eudocima phalonia* (Linnaeus, 1763)	India, China, Indonesia, Korea, Japan, New Guinea, Australia, New Zealand	SGNP, MG, BWS, KWS, AM	–
292.	*Eudocima homaena* (Hübner, 1816)	India, Sri Lanka, China, Myanmar, Malaysia, Indonesia, Singapore, Philippines	SGNP, MG, BWS, KWS, AM	–
293.	*Eudocima hypermnestra* (Stoll, 1780)	India, Sri Lanka, Myanmar	SGNP, AM	–
294.	*Eudocima materna* (Linnaeus, 1767)	India (Uttarakhand, Assam), New Guinea, Australia, Canada, America, French Antilles, Africa	SGNP, MG, KWS	RE
295.	*Oraesia* c.f. *argyrosigna*	DD	MG	DD
296.	*Oraesia emarginata* (Fabricius, 1794)	India, China, Korea, Japan, Australia	MG, AM	–
297.	*Plusiodonta coelonota* (Kollar, 1844)	India (Uttarakhand, Andaman & Nicobar Is.), Sri Lanka, China, Myanmar, Indonesia, Singapore, Philippines, Japan, New Guinea	KWS, MG	RE
	Calpinae, Phyllodini			
298.	*Phyllodes consobrina* Westwood, 1848	India (N.E. India, Andaman Is.), Sri Lanka, Myanmar, Thailand	AM	RE
	Calpinae, Ophiderini			
299.	*Achaea janata* (Linnaeus, 1758)	India, China, Myanmar, Indonesia, Singapore, Philippines, Japan, New Guinea, New Zealand, Australia	SGNP, MG, BWS, KWS, AM	–
300.	*Achaea serva* (Fabricius, 1775)	Indo-Australian Tropics, China, Philippines.	SGNP, MG, BWS, KWS, AM	–
301.	*Bastilla crameri* (Moore, 1885)	India, Sri Lanka, Pakistan, China, Myanmar, Thailand, Indonesia and Malaysia (Borneo)	MG, SGNP, AM, PWS	–
302.	*Bastilla joviana* (Stoll, 1782)	India, Sri Lanka, Pakistan, Bhutan, Nepal, Bangladesh, Myanmar, Thailand, Malaysia, Indonesia, China, New Guinea, Australia	MG, AM	–

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No.	Taxa	Distribution	Collection Sites	Range Notes
303.	*Buzara onelia* (Guenée, 1852)	India, China, Myanmar, Malaysia, Indonesia, Singapore, Philippines	KWS, AM	–
304.	*Parallelia stuposa* (Fabricius, 1794)	India, Sri Lanka, China, Indonesia, Philippines, Japan, Korea	SGNP, MG, AM	–
305.	*Parallelia* sp.	DD	SGNP	DD
306.	*Pindara illibata* (Fabricius, 1775)	India, Sri Lanka, Myanmar, China, Japan, Singapore, Philippines, Indonesia, Malaysia (Borneo)	MG	–
307.	*Ophiusa tirhaca* (Cramer, 1777)	India, China, Japan, Philippines, Australia, S.E. Europe, Africa	SGNP, MG, BWS, KWS	–
308.	*Ophiusa olista* (Swinhoe, 1893)	India, China, Korea, Japan	SGNP, MG	–
309.	*Ophiusa triphaenoides* (Walker, 1858)	India, Sri Lanka, Pakistan, Bhutan, Nepal, Bangladesh, China, Taiwan, Thailand, Myanmar, Sumatra, Indonesia, Malaysia (Borneo)	SGNP	–
Boletobiinae				
310.	*Diomea lignicolora* (Walker, 1858)	Sri Lanka, Thailand, China, Indonesia.	AM	NR
311.	*Diomea* sp.	DD	MG, AM	DD
Aventiinae				
312.	*Laspeyria* sp.	DD	KWS	DD
313.	*Cerynea* c.f. *contentaria*	DD	KWS	DD
Anobinae				
314.	*Plecoptera reflexa* (Guenée, 1852)	India, China, Singapore, Philippines	MG, SGNP	DD
315.	*Tephriopis* c.f. *divulsa*	DD	KWS	DD
316.	*Crithote horridipes* Walker, 1864	India, China, Indonesia and Malaysia (Borneo)	SGNP, KWS	–
317.	*Anoba pectinata* (Hampson, 1896)	India (N.E. Himalaya), Sri Lanka, China, Indonesia and Malaysia (Borneo, Sumatra, Java)	AM	RE
Erebinae, Erebini				
318.	*Erebus ephesperis* (Hübner, 1827)	India (Andaman & Nicobar Is.), Sri Lanka, China, Indonesia, Taiwan, Japan	MG, BWS, AM	RE
319.	*Erebus caprimulgus* (Fabricius, 1781)	India, Sri Lanka, Myanmar	MG, AM	–
320.	*Erebus hieroglyphica* (Drury, 1773)	India (Uttarakhand), Pakistan, Sri Lanka, Bangladesh, Japan, China (including Hong Kong), Taiwan, Cambodia, Laos, Myanmar, Thailand, Vietnam, Indonesia, Philippines, Malaysia, Singapore, Korea	MG, AM	RE
321.	*Erebus macrops* (Linnaeus, 1770)	India, Sri Lanka, Nepal, Myanmar, China	SGNP, MN, MG, PWS, AM, BWS,	–
322.	*Erebus* sp.	DD	MG	DD
323.	*Chilkasa falcata* Swinhoe, 1885	India, Sri Lanka, Nepal, Myanmar, Bhutan, Bangladesh, Thailand, China, Indonesia, Malaysia (Borneo), Philippines	MG	–
324.	*Artena dotata* (Fabricius, 1794)	India, Sri Lanka, China, Indonesia, Malaysia (Borneo), Singapore, Japan	SGNP, MG, BWS, AM	–
325.	*Artena submira* Walker, 1858	India (Tamil Nadu), Bangladesh, Myanmar, Thailand, Vietnam	SGNP, MG	RE
326.	*Hypocala deflorata* Fabricius, 1794)	India, Sri Lanka, Thailand, Nepal, Indonesia, China, Taiwan, Japan, Korea, New Zealand, Australia, South Africa, Madagascar	AM	–
327.	*Hypocala subsatura* (Guenée, 1852)	India (N.W. Himalayas, Uttarakhand, Karnataka, Tamil Nadu), China, E & S Africa	AM, MG	RE
328.	*Chalciope mygdon* (Cramer, 1777)	India (Sikkim, Nicobar Is.), Sri Lanka, China, Indonesia and Malaysia (Borneo), Singapore, Japan	SGNP, MG, KWS	RE
329.	*Grammodes geometrica* (Fabricius, 1775)	India, Sri Lanka, China, Myanmar, Indonesia, Singapore, Taiwan, New Guinea, Australia, Europe, Africa.	SGNP, MG, BWS, KWS, AM	–
330.	*Grammodes stolida* (Fabricius, 1775)	India, Europe, Africa, Yemen	MG, KWS	–

Table 4: Status and Distribution of Moths Recorded from Northern-western Ghats

No.	Taxa	Distribution	Collection Sites	Range Notes
331.	*Trigonodes hyppasia* (Cramer, 1779)	India, Sri Lanka, China, Japan, Australia, Africa.	SGNP, MG, KWS	–
332.	*Mocis frugalis* (Fabricius, 1775)	India (Sikkim), Sri Lanka, Myanmar, China, Japan, Malaysia, Indonesia, Singapore, New Guinea, Australia, Africa	MG	RE
333.	*Mocis undata* (Fabricius, 1775)	India (Uttarakhand, Nicobar Is.), Sri Lanka, China, Myanmar, Indonesia, Singapore, Korea, Philippines, Japan, Australia, Africa, Madagascar	MG, KWS, AM	RE
334.	*Thyas coronata* (Fabricius, 1775)	India (Sikkim, Uttarakhand), Sri Lanka, China, Bangladesh, Myanmar, Thailand, Indonesia, Philippines, Christmas Is., Australia, New Caledonia	SGNP, MG, BWS	RE
335.	*Thyas honesta* Hübner, 1806	India, Sri Lanka, Pakistan, Nepal, Bhutan, Bangladesh, Myanmar, Thailand, Indonesia, Malaysia (Borneo), Philippines	MG, KWS	–
336.	*Serrodes inara* (Cramer, 1779)	India (Tamil Nadu, Kerala, Andhra Pradesh).	SGNP, MG	EN, RE
337.	*Serrodes campana* Guenée, 1852	India, Sri Lanka, China, Bangladesh, Myanmar, Indonesia, Singapore, New Guinea, Australia.	SGNP, MG, AM	–
338.	*Rema costimacula* (Guenee, 1852)	India (Sikkim), China, Singapore, Indonesia, Australia	SGNP	RE
Erebinae, Catocalini				
339.	*Catocala* sp.	DD	SGNP	DD
340.	*Avatha chinensis* (Warren, 1913).	China, Taiwan, Japan	MG	NR
341.	*Attatha regalis* (Moore, 1872)	India (northern India), Vietnam, Thailand, Nepal, China, Philippines	SGNP, MG	RE
342.	*Sympis rufibasis* Guenée, 1852	India, Sri Lanka, Myanmar, Nepal, Thailand, Cambodia, Vietnam, China, Taiwan, Philippines, Indonesia	AM	–
343.	*Sphingomorpha chlorea* (Cramer 1777)	India, Sri Lanka, Nepal, Thailand, China, United Arab Emirates, Oman, Saudi Arabia, Yemen, Egypt, Africa, Uganda, Sudan	SGNP	–
Erebinae, Hypopyrini				
344.	*Spirama retorta* (Clerck, 1764)	India, Sri Lanka, Nepal, China, Myanmar, Thailand, Malaysia, Indonesia, Philippines, Korea, Japan	SGNP, MG, AM, MN	–
345.	*Hypopyra ossigera* Guenée, 1852	India (Assam, Sikkim), China, Indonesia and Malaysia (Borneo)	SGNP, MG, BWS, KWS	RE
346.	*Hypopyra vespertilio* (Fabricius, 1787)	India, Sri Lanka, China, Myanmar, Indonesia, Japan	SGNP, MG, AM, MN	–
Erebinae, Tinolini				
347.	*Calesia dasyptera* (Kollar, 1844)	India, Sri Lanka, Nepal, Bangladesh, Thailand, Laos, Vietnam, China, Myanmar	SGNP, MG	–
348.	*Calesia rhodoteia* Hampson, 1926	Thailand, Myanmar	MG	NR
349.	*Calesia stillifera* Felder, 1874	Sri Lanka, India, Thailand, Cambodia, Vietnam, China, Philippines	KWS	–
Erebinae, Hulodini				
350.	*Ericeia inangulata* (Guenée, 1852)	India (Himachal Pradesh, Uttarakhand), Sri Lanka, China, Bangladesh, Myanmar, Singapore, Japan, New Guinea	SGNP, MG	RE
351.	*Ericeia* c.f. *inangulata*	DD	MG	DD
352.	*Ericeia* c.f. *pertendens*	DD	MG	DD
353.	*Hulodes caranea* (Cramer, 1780)	India (Assam), Sri Lanka, China, Myanmar, Thailand, Indonesia, Singapore, Philippines, New Guinea	SGNP, MG, BWS, AM	RE
Erebinae, Pericymini				
354.	*Pericyma umbrina* (Guenée, 1852)	India	MG	EN
Erebinae, Ercheini				
355.	*Ercheia cyllaria* (Cramer, 1779)	India (Uttarakhand, Nicobar Is.), Sri Lanka, China, Myanmar, Vietnam, Malaysia, Indonesia, Singapore, Japan, Ethiopia	MG, AM	RE
356.	*Ercheia diversipennis* Walker, 1857	India, Sri Lanka, Myanmar, Indonesia, Malaysia (Borneo)	MG	–
357.	*Ercheia* sp.	DD	KWS, AM	DD

Table 4: Status and Distribution of Moths Recorded from Northern-western Ghats

No.	Taxa	Distribution	Collection Sites	Range Notes
358.	*Hypospila bolinoides* Guenée, 1852	India (Central India, Andaman & Nicobar Is.), Sri Lanka, Nepal, Thailand, Vietnam, Cambodia, China, Japan, Korea, Indonesia and Malaysia (Borneo, Java), New Guinea, Australia	SGNP, KWS	RE
	Subfamily Unassigned			
359.	*Dierna acanthusalis* Walker, 1858	India (Tamil Nadu), Sri Lanka, Myanmar	MG	RE
360.	*Egnasia ephyrodalis* Walker, 1858	India (North India), Bangladesh, Sri Lanka.	SGNP, MG	–
361.	*Fodina contigua* Wileman, 1914	India, Sri Lanka, China, Japan, Philippines, Indonesia, Africa	SGNP, MG, BWS, PWS	–
362.	*Hamodes aurantiaca* Guenée, 1852	India (western India, Assam, Sikkim, Andaman Is), Myanmar	SGNP, MG, BWS, AM	–
363.	*Hamodes propitia* (Guerin-Meneville, 1831)	India (Uttarakhand), Bangladesh, Nepal, Myanmar, Thailand, Laos, China, Indonesia, Malaysia (Borneo), Philippines, Australia, Palau, Papua New Guinea	SGNP, MG, BWS, AM	RE
364.	*Ischyja manlia* (Cramer, 1776)	India (Himalayas, Uttarakhand), Sri Lanka, China, Myanmar, Indonesia, Philippines, Australia	SGNP	RE
365.	*Anisoneura aluco* (Fabricius, 1775)	India (northern India, Uttarakhand), China, Myanmar, Indonesia, Malaysia (Borneo), Singapore, Australia	MG, KWS	RE
366.	*Arsacia rectalis* (Walker, 1863)	India (Punjab, Maharashtra, Tamil Nadu), Sri Lanka, Nepal, China, Malaya, Indonesia, Malaysia (Borneo), New Guinea, Australia	SGNP	–
367.	*Bocula xanthostola* Hampson, 1926	Sri Lanka, Indonesia, Malaysia (Borneo).	KWS	NR
368.	*Chrysopera combinans* (Walker, 1858)	India, Sri Lanka, Nepal, China, Thailand, Malaysia, Indonesia, Australia	SGNP, MG, KWS	–
369.	*Episparis liturata* (Fabricius, 1787)	India (Punjab, Kerala, Uttarakhand), Sri Lanka, Myanmar, China, Thailand	SGNP, MG, BWS	RE
370.	*Psimada quadripennis* Walker, 1858	India (Uttarakhand, Andaman & Nicobar Is.), Sri Lanka, China, Myanmar, Indonesia, Singapore	MG	RE
	(xxvi) **Euteliidae**			
	Euteliinae			
371.	*Eutelia favillatrixoides* Poole, 1989	India, Sri Lanka, China	KWS	–
372.	*Penicillaria jocosatrix* Guenée, 1852	India (Uttarakhand), Indo-Australian Tropics, China	KWS	RE
	Stictopterinae			
373.	*Lophoptera squammigera* Guenée, 1852	India (Uttarakhand), Pakistan,Sri Lanka, Bangladesh, Japan, China (including Hong Kong), Taiwan, Cambodia, Laos, Myanmar, Thailand, Vietnam, Indonesia, Philippines, Malaysia, Singapore, Korea	KWS, AM	RE
374.	*Lophoptera squammilinea* Holloway, 1983	India (N.E. Himalaya), Indonesia and Malaysia (Borneo)	MG, KWS	RE
	(xxvii) **Nolidae**			
	Nolinae			
375.	*Selepa celtis* Moore, [1860] 1858	India (Nagaland), Sri Lanka, China, Malaysia, Indonesia, Philippines, Japan, Australia	MG, SGNP, KWS	RE
	Chloephorinae, Chloephorini			
376.	*Carea angulata* (Fabricius, 1793)	India, Sri Lanka, China, Indonesia	MG, AM	–
377.	*Gabala polyspilalis* Walker, 1866	India (Sikkim, Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu)	SGNP	EN
	Chloephorinae, Careini			
378.	Xenochroa sp.	DD	SGNP	DD
	Westermanniinae			
379.	*Westermannia superba* Hübner, 1823	India (western and southern India), Sri Lanka, Indonesia, Singapore	SGNP, MG, BWS, KWS, AM	–

Table 4: Status and Distribution of Moths Recorded from Northern-western Ghats

No.	Taxa	Distribution	Collection Sites	Range Notes
	Risobinae			
380.	*Risoba repugnans* (Walker, 1856)	India (North India, Tamil Nadu), Sri Lanka	MG, AM	RE
381.	*Risoba* c.f. *literata*	DD	SGNP	DD
382.	*Risoba* sp.	DD	MG	–
	Collomeninae			
383.	*Gadirtha* sp.	DD	BWS	–
	(xxviii) **Noctuidae, Plusiinae**			
384.	*Chrysodeixis acuta* (Fabricius, *1775*)	India, China, Indonesia, Japan, Australia, Africa.	MG, KWS, AM	–
385.	*Chrysodeixis eriosoma* (Doubleday, 1843)	India, Malaysia, Indonesia, China, Japan Australia, New Zealand, New Guinea and neighbouring islands in the Pacific Ocean, North and South America; Yemen, Uganda	AM	–
386.	*Ctenoplusia albostriata* (Bremer & Grey, 1853)	China, Indonesia, Korea, Japan, Australia, Fiji, Indo-Australian tropics to New Zealand and Rapa Is.	KWS	–
387.	*Thysanoplusia orichalcea* (Fabricius, 1775)	Southern Europe and Africa to South-east Asia, Australia and New Zealand	MG, KWS, AM	–
	Eustrotiinae			
388.	*Maliattha* sp.	DD	KWS, PWS	DD
389.	*Eustrotia marginata* (Walker, 1866)	India, China, Myanmar, Indonesia	PWS	–
390.	*Ozarba punctigera* Walker, 1865	India, Nepal, Pakistan, China, Myanmar, Korea, Japan, Australia, Central and South Africa	KWS	–
	Bagisarinae			
391.	*Pardoxia graellsi* (Feisthamel, 1837)	India, China, South Europe, Africa, Mauritius, Aden	SGNP, MG	–
392	*Xanthodes transversa* Guenée,1852	India (Andaman & Nicobar Is.), Myanmar, China, Japan, Ryukyu Is., Singapore, Indonesia, Australia, Vanuatu	SGNP	–
393.	*Chasmina candida* (Walker, 1865)	Indo-Australian tropics east to Fiji	MG,KWS	–
394.	*Chasmina fasciculosa* Walker, 1858	Sri Lanka, China, Philippines	SGNP	NR
395.	*Sphragifera rejecta* (Fabricius, 1775)	India, Sri Lanka, China, Myanmar, Philippines	MG	–
	Acontiinae, Acontiini			
396.	*Acontia* sp.	DD	SGNP	DD
	Acontiinae, Aediini			
397.	*Aedia leucomelas* (Linnaeus, 1758)	Europe and Indo-Pacific regions.	SGNP, MG, KWS, AM	–
398.	*Aedia* sp.	DD	KWS	DD
	Pantheinae			
399.	*Trisula variegata* Moore, 1858	India (northern India, Tamil Nadu)	MG	EN, RE
400.	*Belciana hemodi* Felder 1874	India (Tamil Nadu), Sri Lanka, Indonesia and Malaysia (Borneo)	MG	RE
401.	*Donda eurychlora* (Walker, 1858)	India, Indonesia, Malaysia (Borneo)	MG	–
	Agaristinae			
402.	*Aegocera bimacula* Walker, 1854	India (Central India, Sikkim), Sri Lanka	SGNP, MG	RE
403.	*Episteme adulatrix* (Kollar, 1844)	India (Jammu & Kashmir, Himachal Pradesh, Punjab, Maharashtra, Karnataka, Kerala, Malabar, Tamil Nadu, Assam) Nepal, China, Myanmar	MG,KWS	–
	Heliothinae			
404.	*Helicoverpa assulta* (Guenée, 1852)	Old World (including Pacific) tropics	SGNP, KWS, AM	–
	Condicinae			
405.	*Condica conducta* Walker, 1857	Africa (Congo, South Africa)	KWS, AM	NR

Table 4: Status and Distribution of Moths Recorded from Northern-western Ghats

No.	Taxa	Distribution	Collection Sites	Range Notes
406.	*Condica illecta* (Walker, 1865)	India, China, Japan, Australia, tropical Pacific	KWS, AM	–
	Eriopinae			
407.	*Callopistria mailliardi* (Guenée, 1862)	India, Sri Lanka, Russia, China, Philippines Japan, Indo-Australia, Pacific tropics, Africa	KWS	–
408.	*Callopistria callopistrioides* (Moore,1881)	India (N.E. Himalaya), Myanmar, Indonesia, Malaysia (Borneo), Philippines	SGNP, AM	RE
	Noctuinae, Caradrinini			
409.	*Athetis delecta* (Moore, 1881)	India, Nepal, China	SGNP, MG	–
410.	*Athetis* sp.	DD	SGNP	DD
411.	*Callyna monoleuca* Walker, 1858	India, Sri Lanka, China, Myanmar, Indonesia, New Guinea	SGNP	–
	Noctuinae, Glottulini			
412.	*Polytela gloriosa* Fabricius, 1781	India	KWS	EN
	Noctuinae, Prodeniini			
413.	*Spodoptera litura* (Fabricius, 1775)	India (eastern India), China, Indo-Australian Pacific Tropics and Sub-tropics	SGNP, MG, KWS, AM	RE
414.	*Spodoptera mauritia* (Boisduval, 1833)	China, Japan, Indo-Australian and Pacific Tropics	PWS	–
	Noctuinae, Dypterigiini			
415.	*Trachea* c.f. *auriplena*	DD	KWS	DD
	Noctuinae			
416.	*Noctua* c.f. *orbona*	DD	SGNP	DD
417.	*Xestia semiherbida* (Walker, 1857)	India (North India), Taiwan	SGNP	RE
418.	*Axylis* sp.	DD	BWS	DD

Abbreviations used in the text and table

AM = Amboli; BWS = Bhimashankar Wildlife Sanctuary; DD = data deficient; EN = Endemic to India; KWS = Koyna Wildlife Sanctuary; MB = Mahabaleshwar; MG = Malshej Ghat; MN = Matheran; NR = New record to India; PWS = Phansad Wildlife Sanctuary; RE = Range extension; SGNP = Sanjay Gandhi National Park, –: Nothing to mention

DISCUSSION

After the Victorian era (Hampson 1892-1896; Dudgeon *et al.* 1897; Bell and Scott 1937), this study has now contributed to the work carried out in 1962 by Shull and Nadkerny, who recorded 180 species over four months in Dangs, Gujarat; Saha and Raychaudhuri (1998) recorded 31 species in a year long study in Jalpaiguri, West Bengal; Rose (2002) recorded 47 species in seven years from Cherrapunji, Meghalaya; Chandra (2007) recorded 142 species between 2001 and 2004 in Madhya Pradesh and Chhattisgarh, and most recently Smetacek (2008) published a list of 887 species from three locations in Uttarakhand compiled over 30 years. This indicates that moth studies have been progressing at a slow pace in our country, and lack of literature and expertise are the prime reasons. The current study, with a checklist of 419 species from Maharashtra, is the first extensive study on moths. More surveys will certainly result in adding to the numbers of species already known.

The moth fauna of Malshej Ghat, Amboli and Koyna wildlife sanctuaries have shown high endemism and many new records for India. Amboli and Koyna wildlife sanctuaries need more detailed sampling as these areas have been largely unexplored for moth studies. Extensive sampling at Sanjay Gandhi National Park resulted in a number of range extensions for northern Western Ghats, it is therefore likely that intensified sampling effort may result in additional records and range extensions from the other sites.

As our objective was to prepare an inventory of moth species in the study area, the numbers arriving at the light trap were not recorded, and hence, no quantitative comparisons between study sites were conducted. Future studies can now include ecological studies on these species, life histories, habitat preferences, moth assemblage composition, especially of endemic species, to provide information relevant to habitat restoration and species conservation programmes.

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STOCKING FOR THE FUTURE: GENETIC AND DEMOGRAPHIC CORRELATES OF WESTERN TRAGOPAN *TRAGOPAN MELANOCEPHALUS* IN CAPTIVITY

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Western Tragopan *Tragopan melanocephalus* is endemic to the Western Himalaya and is listed as Vulnerable (VU) C2a (i) in IUCN Red Data List (2011) and Schedule I of the Indian Wildlife (Protection) Act, 1972. Given the exigency of ensuring its conservation, *in situ* conservation requires *ex situ* conservation efforts for its continued survival. However, for successful captive breeding of these birds, it is critical to maintain a genetically and demographically healthy population. In this context, pedigree records through development and maintenance of a studbook offer a viable option to undertake scientific management of captive stock. We discuss the genetic and demographic status of the Western Tragopan population in the only captive facility (Sarahan Pheasantry) for the bird. We used studbook data that was analysed using population management program PM2000. The demographic traits of the population indicated a growing, but unstable population. The genetic analysis reveals a genetically healthy population with inequitable founder representation. It is suggested that population size should be grown rapidly, with a focus on increasing the 'effective' population size and breeding all the founders, thereby augmenting the genetic variability.

Key words: captive breeding, studbook, Single Population Analysis and Record Keeping System (SPARKS), PM2000, genetic analysis, demographic analysis

INTRODUCTION

Western Tragopan *Tragopan melanocephalus* is endemic to north-west Himalaya. This medium-sized pheasant, whose males are brightly coloured, possessing lappets, and fleshy horns to attract females during the breeding season, is among the rarest of the Himalayan pheasants (Ramesh 2003). Being a habitat specialist, loss of habitat poses a major threat for this species. This threat is compounded by the low breeding success, induced by direct and indirect anthropogenic disturbances. Hunting of this bird for their meat and bright plumage is another major threat for this endangered bird (BirdLife International 2001). No reliable population estimate is available for the bird; however, current estimates suggest that the wild population of Western Tragopan is lower than 5,000 individuals (Gaston *et al.* 1983; Johnsgard 1986; BirdLife International 2001; Ramesh 2007). This population is highly fragmented and reported to be declining, which adds to the risk of extinction of this bird in the wild (Ramesh 2003). The species is thus listed as Vulnerable (VU) C2a (i) in IUCN Red Data List (2011) and Schedule I of the Indian Wildlife (Protection) Act, 1972. The future of the species in the wild is thus in jeopardy, making its *ex situ* conservation through captive breeding an important conservation strategy and an insurance against extinction (Lacy 1994; Sillero-Zubiri *et al.* 1997; Budd and Leus 2011). Indeed the captive population can be used in future to infuse variation in wild population and can also be reintroduced in wild habitats, where the species has been eliminated (Foose and Ballou 1988).

A conservation breeding programme for Western Tragopan has thus been initiated at Sarahan Pheasantry in Himachal Pradesh. Incidentally, Sarahan Pheasantry is the only facility in India, and also in the world, to have captive stock of this species. Recently, two birds from Sarahan have been transferred to Kufri Zoological Park (Himachal Pradesh) for display purpose. For the successful captive breeding of the animal, it is important to maintain a genetically healthy population, i.e., maximum genetic diversity should be present in the breeding population to avoid the deleterious effects of inbreeding on future populations (Lacy 1995, 1997; Saccheri *et al.* 1998; O'Grady *et al.* 2006). Successful genetic and demographic management requires complete and accurate pedigree records, thus maintaining a studbook is primary for the *ex situ* management of any species (Ballou and Foose 1995; Foose and Weise 2006). Studbook has long been successfully used for captive breeding management of many species (Glatston 2001; Ralls and Ballou 2004; Budd and Leus 2011). A studbook for Western Tragopan has already been prepared by the Wildlife Institute of India in collaboration with the Wildlife Wing of Himachal Pradesh Forest Department (Lakshminarasimha *et al.* 2011). The present paper discusses the genetic and demographic status of the captive population of Western Tragopan using the data of the aforementioned studbook.

METHODOLOGY

The only captive population (n = 21) of Western Tragopan in India (Sarahan Pheasanty and Kufri Zoological Park, Himachal Pradesh) were assessed for genetic and demographic viability. Chronological data on the events and lineage of birds contributing to the present population were obtained from the records maintained at the Sarahan Pheasantry. Studbook was analysed using Single Population Analysis and Record Keeping System (SPARKS) 1.5 software (ISIS 2004), and a report was generated after assigning permanent studbook numbers to all the individuals in the population. Subsequently, the SPARKS dataset was imported as *.prn and *.ped files for demographic and genetic analyses to PM2000 software (Pollack *et al.* 2001). The PM2000 was then used to produce census report, life tables, founder statistics, various important genetic variables, possible pairings and population planning.

RESULTS

As on August 2011, there were 21 individuals of Western Tragopan in captivity; 19 in Sarahan Pheasantry (10 males and 9 females) and two males in Kufri Zoological Park, transferred from Sarahan in 2009. A total of 37 individuals have been kept in the Sarahan Pheasantry so far (1990 to mid 2011), however, pedigree details are available for only 22 birds, as the remaining 15 birds did not contribute to the population size. Therefore, only 22 birds were included in the population analysis.

A study of census reveals that although the population grew at a steady rate in the last ten years, there has been decline in the population size since 2009 (Fig. 1). The details of the census over the years are provided in Table 1.

Various characteristics of demography, such as age distribution, age specific fertility and age specific mortality are summarized in the life table obtained for both the sexes (Table 2). Life table suggests that the male population is growing annually (λ) at a rate of 1.07 and instantaneously (r) at a rate of 0.06, while female population is declining annually at a rate of 0.94 and instantaneously at a rate of -0.07. The average age at which the animal is producing offspring, i.e., the generation length (T) is shorter in case of females at 4.18 years, as compared to males at 6.45 years. Age pyramid suggests that most individuals in the given population are in the breeding age (Fig. 2). However, absence of animals in certain age classes, like juvenile and neonatal, reflected as a gap at the base of the age pyramid. Also in certain age classes, the population is prominently skewed towards one of the sex. Age specific mortality rate (Qx) for female population is high for 0-2, 2-4, 8-10, 10-12 and 12-14 age classes (Fig. 3). Age specific survivorship (Ix) is higher for males across all the age classes (Fig. 4). Age specific fertility rate or fecundity (Mx) is slightly skewed towards younger age classes for females (Fig. 5). Therefore, reproductive value (Vx) is higher for females in the younger age classes, while it is higher for males in the older age classes (Fig. 6).

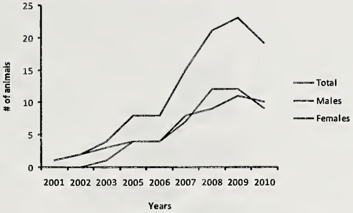

Fig. 1: Census trends of Western Tragopan in Sarahan Pheasantry

Results of genetic analysis show that 86% genetic diversity is being retained by the Western Tragopan population at Sarahan Pheasantry. The gene value, which is an expression of expected heterozygosity if a given population is bred randomly (Pollack *et al.* 2001) was 0.86, which is relatively moderate. Although the current population size is 19, mean 'effective' population size (Ne), i.e., the randomly breeding ideal population that would hold the same amount of variance in allele frequency as the present population (Lacy 1995) is

Table 1: Census data of Western Tragopan in Sarahan Pheasantry

Year	Total	Males	Females	Unsexed	Wild Born	Captive Born
2001	1	1	0	0	1	0
2002	2	2	0	0	2	0
2003	4	3	1	0	4	0
2005	8	4	4	0	7	1
2006	8	4	4	0	7	1
2007	15	8	7	0	7	8
2008	21	9	12	0	9	12
2009	23	11	12	0	9	10
2010	19	10	9	0	9	10

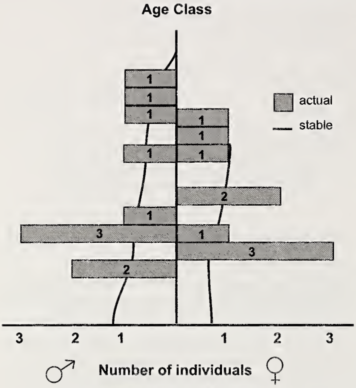

Fig. 2: Age distribution of living Western Tragopan population in Sarahan Pheasantry

only 10.63 over the past 1.3 generations. The current Ne is even lesser at 8.89. Mean kinship (MK), which is the most important genetic parameter for deciding which of the birds in the population should be given priority for breeding (Lacy 1995; Ballou and Lacy 1995; Montgomery *et al.* 1997), is high for most of the animals (Table 3). Population mean kinship is high at 0.14, but has the potential to be lowered to 0.06. It is pertinent to note that population's mean inbreeding coefficient (F) is zero. Individual statistics also reveal zero mean inbreeding in current Western Tragopan population, implying that none of the birds in Sarahan Pheasantry are inbred (Table 4).

Table 2: Age distribution of living Western Tragopan population

Age (x)	Male Actual	Male Stable	Female Actual	Female Stable
0	0	1.16	0	0.81
1	0	1.09	0	0.82
2	2	0.97	0	0.74
3	0	0.85	3	0.70
4	3	0.80	1	0.75
5	1	0.75	0	0.80
6	0	0.71	2	0.86
7	0	0.67	0	0.92
8	1	0.63	1	0.98
9	0	0.59	1	1.05
10	1	0.55	1	0.56
11	0	0.52	0	0.00
12	1	0.49	0	0.00
13	1	0.23	0	0.00
14	0	0.00	0	0.00

The founder statistics show that there are six founders with living descendants in the population. However, the Founder Genome Equivalents (FGE), which is the number of founders that would retain the same level of genetic diversity as the present population, if all the founders are equitably represented and retain all the alleles (Ballou and Foose 1995; Lacy 1995), is 3.6. Founder statistics further suggest that values of Founder Genome Equivalents and Founder Genome Surviving are low because studbook numbers 00001 (Abbu) and 00004 (Neelu) are over-represented, while studbook number 00006 (Moti) is under-represented. Studbook numbers 00007 (Rekha), 00009 (Shalu) and 00010 (Sanju) have not been represented at all, these are wild origin individuals that can be potential founders (Table 5).

DISCUSSION

The successful captive breeding of Western Tragopan at Sarahan Pheasantry has indicated that the species is capable of reproducing *ex situ*, making it possible for the managers to address the challenges of conservation breeding of the species to successfully raise a stock for future. However, the present captive population of Western Tragopan as indicated by the above presented demographic characteristics is not stable. Life table predicts a negative growth of female Western Tragopan population indicating that the female population is not demographically healthy. High Qx for female population under certain age classes also implies that the females are at a higher risk of death in these age classes than the males. Thus, it is of importance to identify the factors which are negatively affecting the female population. Skewed Mx towards younger age classes for females suggest that younger

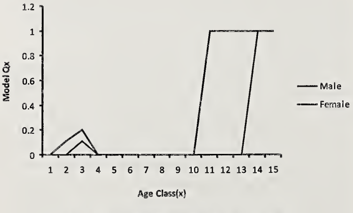

Fig. 3: Comparison of male-female mortality

females reproduce more than males in the same age class, while older males reproduce more than females in the same age class. Thus, there are probabilities that males would live longer and produce more number of offspring than females in the population. Age distribution of Western Tragopan presented as an age pyramid reveals that there are gaps at the base of the age pyramid, which may be deleterious for the population, thus neonatal and juvenile mortality needs to be checked. The caveat is that there is further scope for demographic understanding, as the present analysis is constrained by low population size. PM2000, which is an age-based model, smoothes the data by providing average for the age class, but since the given population is small, fewer animals have passed through each age class, making it difficult to make reliable predictions about the population. For this purpose it is important that the population should be rapidly increased and analysis repeated. As an alternative the population can also be analysed using stage-based models that are increasingly being viewed as a new approach for assessing small captive populations (Faust 2003).

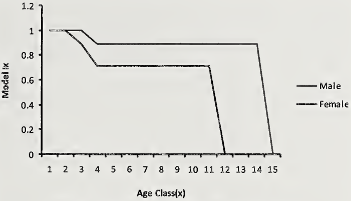

Fig. 4: Comparison of age specific survivorship

The present population is genetically healthy as indicated by absence of inbreeding and therefore inbreeding depression (Foose and Ballou 1988; Lacy 1995, 1997). However, genetic analysis reveals that the mean kinship is high for most individuals; thus, caution should be taken to plan breeding of these animals if it is desired to keep mean inbreeding to low levels. Kinship should also be minimized to retain maximum genetic diversity in this population with unequal founder representation (Montgomery *et al.* 1997). Further, Ne is low, indicating that the population is not efficiently maintaining genetic diversity from one generation to the next (Ballou and Foose 1995). Therefore, efficient management intervention should be undertaken that would involve increasing the 'effective' population size (Ne), than merely increasing the size of the small population. This can possibly be achieved by equalizing the sex ratio, decreasing the variability in family size, checking the fluctuations in the population size over generations and avoiding overlap of generations. Presently, it is of utmost importance to increase the population size, control fluctuations in the population size and to optimize the sex ratio (Templeton and Read 1983; Tangley 1984; de Boer 1989, 1994; Foose and Ballou 1988; Lacy 1995; Provine 2004; Lees and Wilcken 2009).

It is pertinent to reiterate that since the Western Tragopan population in Sarahan Pheasantry is under an active Conservation Breeding programme, it is helpful to breed all

Table 3: Life table for male and female Western Tragopan population

Age	Males					Females				
	Qx	Px	Lx	Mx	Vx	Qx	Px	Lx	Mx	Vx
0	0.000	1.000	1.000	0.000	1.000	0.000	1.000	1.000	0.000	1.000
1	0.000	1.000	1.000	0.070	1.065	0.110	0.890	1.000	0.060	0.993
2	0.110	0.890	1.000	0.000	1.122	0.200	0.800	0.890	0.100	1.032
3	0.000	1.000	0.890	0.000	1.270	0.000	1.000	0.712	0.330	0.984
4	0.000	1.000	0.890	0.000	1.353	0.000	1.000	0.712	0.400	0.613
5	0.000	1.000	0.890	0.250	1.441	0.000	1.000	0.712	0.200	0.200
6	0.000	1.000	0.890	0.500	1.269	0.000	1.000	0.712	0.000	0.000
7	0.000	1.000	0.890	0.510	0.820	0.000	1.000	0.712	0.000	0.000
8	0.000	1.000	0.890	0.330	0.330	0.000	1.000	0.712	0.000	0.000
9	0.000	1.000	0.890	0.000	0.000	0.000	1.000	0.712	0.000	0.000
10	0.000	1.000	0.890	0.000	0.000	1.000	0.000	0.712	0.000	0.000
11	0.000	1.000	0.890	0.000	0.000	1.000	0.000	0.000	0.000	0.000
12	0.000	1.000	0.890	0.000	0.000	1.000	0.000	0.000	0.000	0.000
13	1.000	0.000	0.890	0.000	0.000	1.000	0.000	0.000	0.000	0.000
14	1.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000

Qx = mortality; Px = survival; Lx = cumulative survivorship; Mx = fecundity; Vx = expected future reproduction the founders extensively, preferably with other founders. Moreover, all the founders in the population should be given equal chances to breed; the under-represented animals should be given priority when planning breeding, while the over-represented stock should not be bred, not at least for the conservation breeding (Foose and Ballou 1988; de Boer 1989, 1994; Foose and Weise 2006; Ballou and Foose 1995). The three wild origin individual that have not been bred should also be bred to increase the genetic diversity of the population. In addition, it is desirable that new wild origin individuals be added to the population, since it is suggested for most captive breeding programme to have 20-30 founders (Foose and Ballou 1988; Lees and Wilcken 2009). But it would be difficult in case of Western Tragopan to procure wild animals given its Vulnerable status; therefore wild origin individual animals should only be added if the goal of the program is reintroduce the birds in the wild, otherwise the captive population should be maintained as a self-sustaining population (Lees and Wilcken 2009). It is also important to ascertain founder kinship, as the genetic diversity (heterozygosity and allelic diversity) retained in the population is a function of relationship to the base population (i.e., founder individuals) (Ralls and Ballou 2004). In captive breeding programmes, the founders are assumed to be unrelated unless there are evidences against the same (Lacy *et al.* 1995; Ballou and Foose 1995; Jones *et al.* 2002; Russello and Amato 2004, 2007). The genetic analysis was therefore performed with an assumption that the founder individuals were drawn from unrelated populations (both wild and captive). Given the absence of detailed location information and DNA analysis, such an assumption needs to be validated. For instance, as per the records, the five birds [Studbook# 00001 (Abu), 00006 (Moti), 00004 (Neelu), 00007 (Rekha) and 00005 (Rani)] were rescued from Daranghati Wildlife Sanctuary, with all but Rekha and Moti being rescued in different time scale. It is, therefore, difficult to place whether or not these are from the same population within Daranghati. These uncertainties and gaps could be effectively addressed by DNA profiling these birds as has been done for another endangered bird, Whooping Crane *Grus americana* (Jones *et al.* 2002).

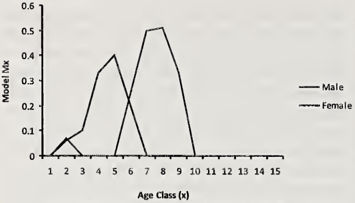

Fig. 5: Comparison of male-female fecundity

Population Planning and Management

Association of Zoos and Aquariums (AZA) Species Survival Plan (SSP) recommends certain population genetic management goal, i.e. 90% genetic diversity for 100 years.

Table 4: Individual statistics

Studbook #	Sex	Sire	Dam	Age	Known	F	MK	KV	FOKE	Progeny	Additional Ids
00001	M	WILD	WILD	13	100	0	0.09	0.08	3.8	2	Abbu 2259q
00002	M	WILD	WILD	12	100	0	0.10	0.10	4.0	5	Raja 2256q
00003	M	WILD	WILD	10	100	0	0.09	0.10	3.5	4	Joney 2258q
00004	F	WILD	WILD	10	100	0	0.09	0.08	3.8	2	Neelu 2260q
00005	F	WILD	WILD	9	100	0	0.10	0.10	4.0	5	Rani 2256q
00006	M	WILD	WILD	8	100	0	0.03	0.03	1.0	1	Moti 2268q
00007	F	WILD	WILD	8	100	0	0.00	0.00	0.0	0	Rekha 2266q
00008	F	00001	00004	6	100	0	0.16	0.13	6.5	4	Ruchi 2267q
00009	F	WILD	WILD	6	100	0	0.00	0.0	0.0	0	Shalu 2283q
00010	M	WILD	WILD	5	100	0	0.00	0.0	0.0	0	Sanju 2284q
00013	M	00003	00008	4	100	0	0.16	0.16	6.5	1	Shiv 2286q
00014	M	00001	00004	4	100	0	0.12	0.12	4.8	0	Golu 2278q
00015	M	00002	00005	4	100	0	0.13	0.14	5.0	0	Gudu 2281q
00017	F	00002	00005	4	100	0	0.14	0.13	5.5	1	Sheela 2276q
00018	F	00003	00008	3	100	0	0.15	0.14	6.0	0	Seema 2289q
00019	F	00002	00005	3	100	0	0.13	0.13	5.0	0	Lata 2290q
00021	F	00003	00008	3	100	0	0.15	0.14	6.0	0	Heena 2288q
00022	M	00013	00017	2	100	0	0.18	0.18	7.0	0	Teenu 2291q
00023	M	00006	00016	2	100	0	0.09	0.10	3.8	0	Monu 2292q

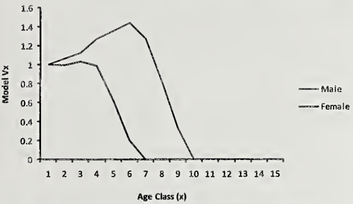

Fig. 6: Comparison of male-female reproductive value

Population modelling of captive Western Tragopan in Sarahan Pheasantry in PM2000 suggests that for achieving the population genetic management, a large number of birds would be required. Such target is difficult to achieve in the present situation, since Sarahan Pheasantry is the lone holding institution for the breeding of Western Tragopan in the entire world. Hence, a feasible genetic management goal of maintaining 90% genetic diversity for 50 years is suggested; for which a population of 52 individuals needs to be maintained with the addition of one founder per year for the next 50 years. This goal though can be achieved even with a smaller number of founders, if the genetic and demographic structure of the population is improved by breeding all founders equally and applying such practices in future that conserve maximum genetic diversity. It is, however, recommended that in case it is not possible to add new founders, as mentioned earlier, the 'effective' population size (Ne) should be rapidly increased manifold (theoretically around 500 individuals) (Lees and Wilcken 2009).

In addition, it is suggested that breeding should be done according to the pairing recommendations made in the Western Tragopan studbook (Lakshminarasimha *et al.* 2011) as the pairing options in the studbook are provided on the basis of mean kinship and inbreeding coefficient. Since the entire pedigree for the Western Tragopan population is known, these mating recommendations are reliable and it is further helpful to consider breeding history of specific pairs. The small population, thus, can be successfully managed by avoiding inbreeding and retaining maximum gene diversity. Lastly, it is desirable that an additional captive breeding centre for the species be established in the region, as keeping the entire captive population at one place (Sarahan Pheasantry) makes it vulnerable to stochastic events. The captive population can also be maintained as metapopulations (Lacy 1994; Sillero-Zubiri *et al.* 1997).

In conclusion, the Western Tragopan captive population holds great promise for successful *ex situ* conservation of the species. The genetic and demographic status of the population presented here is expected to guide scientists and managers towards the achievement of this goal.

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Table 5: Founder statistics

Studbook #	Sex	Age	Representation	Contribution	Allele Retention	Potential Retention	Descendants
00001	M	13	0.1875	1.8750	0.7475	1.0000	6.00
00002	M	12	0.2000	2.0000	0.9050	1.0000	5.00
00003	M	10	0.1750	1.7500	0.8765	1.0000	4.00
00004	F	10	0.1875	1.8750	0.7490	1.0000	6.00
00005	F	9	0.2000	2.0000	0.9040	1.0000	5.00
00006	M	8	0.0500	0.5000	0.5000	1.0000	1.00
00007	F	8	0.0000	0.0000	0.0000	1.0000	0.00
00009	F	6	0.0000	0.0000	0.0000	1.0000	0.00
00010	M	5	0.0000	0.0000	0.0000	1.0000	0.00

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POPULATION ESTIMATION OF MAMMALS: VALIDATION OF THE RESULTS FROM LARGE MAMMAL CENSUS AND LONG-TERM STUDY FROM RAJIV GANDHI NATIONAL PARK (NAGARHOLE NP)

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Population estimates of mammals provide considerable insights for conservation strategies, but only a few systematic population studies and annual census operations have given some direction to this effort. Even in these attempts, the methods adopted for estimating numbers vary substantially, and are usually not coupled with efforts to validate the results obtained, e.g., results of 1997 annual mammal census operation of Rajiv Gandhi National Park, southern India. The methods adopted for these operations were similar to each other. Hence, the census data of 1997 were reanalyzed using updated versions of data processing protocols. The overall results indicate that density estimates of all the species during the census using block counts were an underestimation, while line transect estimates were overestimates for several species. It is suggested that well-planned census operations, with focused training programmes and involvement of experts, may provide reasonably acceptable estimates.

Key words: population estimation, line transect method, block count, large mammals

INTRODUCTION

Estimating population density of animal species, paticularly mammals that attract conservation interest (Krishnan 1972; Ramachandran *et al.* 1986), is an important tool for their conservation and population management (Varman 1988; Karanth and Sunquist 1992; Varman and Sukumar 1995; Sutherland 1997). However, estimating animal numbers in a tropical forest habitat is difficult mainly because of poor visibility and relatively low density of some species resulting in inadequate sample sizes, for obtaining statistically precise results (Koster and Hart 1980; Varman and Sukumar 1995). Importantly, no systematic or scientific approaches have been followed to estimate population densities, except in one or two locations (covering about 2.5-4% of the distribution area). For example, the Asian Elephant *Elephas maximus* is distributed in 25,500 sq. km (Sukumar *et al.* 2006) of habitat in southern India, but only in one or two places, covering about 2.5-4% of its distribution area, have systematic or vigorous population estimations of the species been carried out (Karanth and Sunquist 1992; Varman and Sukumar 1995).

Population numbers that are available for species such as the Asian Elephant originate only from census programs. So far, systematic census programs have been initiated only for the Asian elephant, and since its inception, in 2002, three favourable census operations have been conducted (AERCC 2002, 2006; ANCF 2007). Though these census operations are assumed to be successful, their results are neither validated nor have they been compared with other long-term population studies on the species.

Comparison of results of long-term study with that of census programs is not possible for all species as they focus on one or two charismatic species; also, the methods adopted are substantially different. Long-term population studies (Karanth and Sunquist 1992; Varman and Sukumar 1995) follow the line transect direct method (Burnham *et al.* 1980; Buckland *et al.* 1993) of density estimates, while census programs depend on a combination of randomised block counts, direct or indirect line transect methods and waterhole counts (AERCC 2002, 2006; ANCF 2007). The most rigorous comparison of methods originate from the census program carried out at Rajiv Gandhi National Park in 1997, where both the line transect direct method and randomised block counts were followed to estimate the population densities of mammals (Varma and Venkataraman 1998). This is also a region where rigorous application of the line transect direct method was made by Karanth and Sunquist (1992) to estimate densities of similar taxa.

Although, since 2002 there has been substantial interest in estimation of mammal population numbers, no comparable effort towards validating census results has been made. Due to the absence of long-term studies on population estimates, and the fact that methods adopted by long-term studies and census operations are largely different, it was decided that the results of the 1997 census be reanalysed with updated versions of data processing protocols. The aim was to estimate population densities for large mammals through both randomised block count and line transect methods. The goal also was to compare the results obtained through either block or line transect methods or from a long-term study, and identify the advantages and disadvantages of using either

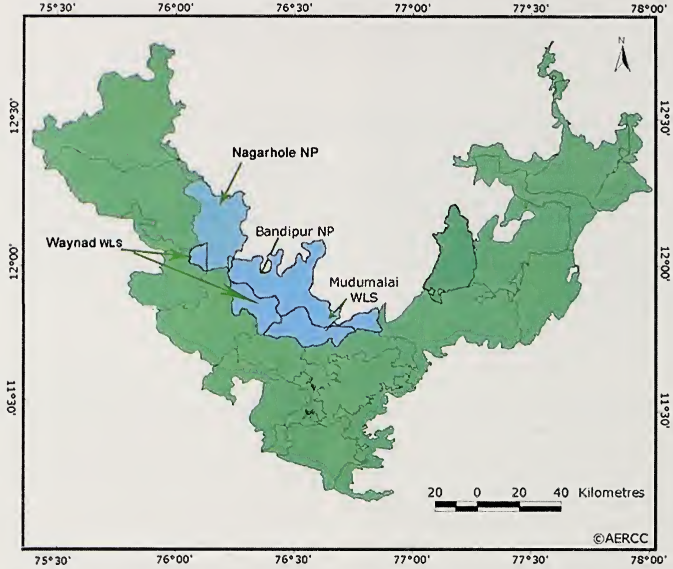

Fig. 1: Rajiv Gandhi National Park and adjoining forest divisions among different elephant divisions in Elephant Reserve Number 7

block or line transect methods or both. It is believed that this validation of the census results would act as a benchmark, particularly in taking a decision on choice of methods for future census operations.

MATERIAL AND METHODS

Study area and mammals

The Rajiv Gandhi National Park (formerly known as Nagarhole NP) is located between 11° 50'-12° 15' N and 76° 0'-76° 15' E, adjoining Bandipur National Park in Karnataka and Waynad Wildlife Sanctuary in Kerala (Fig. 1). The terrain of the Park is undulating with small hills and the average elevation is around 800 m above msl with the highest point occurring at Masal *betta* (950 m above msl). The major water sources for the Park are the rivers Lakshmanatirtha, Sarati Hole and Nagarhole, and there are also a number of other perennial and seasonal streams. The annual rainfall declines from west to east, from 1,500 to 900 mm; most of the rainfall occurs between June and September.

The vegetation type (Fig. 2) of the Park is dominated by mixed deciduous forests. The other forest types found in this area are dry deciduous, moist deciduous, semi-evergreen and scrub. Apart from these forest types, microhabitats such as swampy grasslands are also found. The Park has man-made forests, with Teak *Tectona grandis* and Eucalyptus *Eucalyptus* sp. plantations; an extensive teak plantation covering 9,000 ha was raised before the area was notified. Lantana *Lantana camara* and Eupatorium *Chromolaena odoratum* are proliferating in the Park.

The mammals considered for the long-term study and census operation were Spotted Deer *Axis axis*, Sambar *Cervus unicolor*, Indian Muntjac *Muntiacus muntjak*, Asian Elephant *Elephas maximus*, Gaur *Bos gaurus*, Hanuman Langur

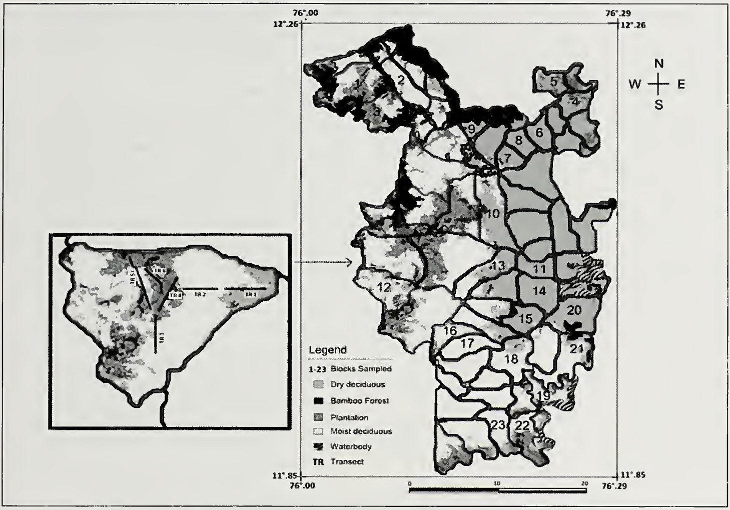

Fig. 2: Rajiv Gandhi National Park with vegetation types, blocks sampled and the location of transect lines used for the census operation

Semnopithecus entellus, Wild Pig *Sus scrofa* and Indian Giant Squirrel *Ratufa indica*. Common and scientific names used for these mammals are based on Menon (2003).

METHODS

Block count

A randomized block count method (Fig. 2) was used during the 1997 census. A total of 24 blocks (compartments) were chosen (from a total of 62 blocks identified for the Park) with the expectation that this would represent three different vegetation types, i.e., dry deciduous, moist deciduous and teak plantations. A total of 15 blocks for dry deciduous forest, 5 for moist deciduous forest and 4 for the teak plantation were chosen; the total sampled area covered was 295 sq. km. This constituted 151 sq. km in dry deciduous forest, 55 sq. km in moist deciduous forest and 89 sq. km in teak plantation. A total of 23 field parties walked in their respective blocks from 6:00 hrs to 18:00 hrs covering as much area as possible and counting the animals sighted. For each sighting, the number of animals seen, their age and sex class were noted.

Line transect method

Permanent transect lines of 2-4 km (Fig. 2), which were laid in different habitats by Karanth and Sunquist (1992), were used during the survey. The total distance walked during this period was 252 km. Each transect was covered once from 7:00-9:30 hrs and once from 16:00-18:30 hrs. For each animal sighted, the perpendicular distance from the centre of the group to the transect line was recorded, in addition to details of age, sex and group composition.

Data processing

Block count

The area for each block and vegetation type was calculated by digitising vegetation and forest compartment (blocks) maps. The block map was superimposed on the vegetation map. The dominant vegetation type in each block was noted and its area added to the total area of that vegetation type. Initially the areas of the blocks were calculated using GIS software IDRISI for Windows (version 1), and later it was updated through ERDAS 8.4 (LEICA Geosystems).

Densities of mammals in a sampled area were calculated by dividing the number of animals sighted in a given vegetation type by the total area of the vegetation type. The densities were also calculated separately for each vegetation type. The total density for a given species occurring in each vegetation type was calculated by multiplying the sampled area density in each vegetation type by the total area of that vegetation type in the Park. This gave the abundance of each species sighted during the census for each habitat type.

As the sample size obtained for each species was low for each vegetation type, no attempts were made to calculate the 95% confidence interval for the numbers estimated for each habitat. However, sightings for all the habitats were pooled, and the lower and upper limits of 95% confidence intervals were calculated for the total number of individuals estimated for each species for the entire Park. The variance for the number of individuals for each species for each block and area of each block was calculated using Choudhury (1991). The total number of individuals of each species was divided by the total area of the blocks sampled to obtain the population density of each species. The population density was multiplied by the total area of the Park to arrive at the total number of individuals for each species. The variance and standard error (SE) associated with the total number of individuals for each species was calculated to arrive at 95% confidence intervals of the total number estimated for each species (Choudhury 1991).

Line transect method

For the basic analysis, animal sightings were categorised into 10 m distance class intervals (from 0 to 100 m). The density of groups was arrived at using the program DISTANCE 5.0. To estimate animal density, the density of groups was multiplied by the mean group size. The standard error (SE) of the mean estimate was arrived at following Goodman (1960), and 1.96 SE was taken as the 95% confidence interval [see Varman and Sukumar (1995) for more details].

RESULTS

Block count

The density of Spotted Deer was highest in all three vegetation types, followed by elephants. In the three habitats put together a total of 705 elephants were estimated and the number of animals estimated for Spotted Deer, Hanuman Langur, Gaur, Sambar, Muntjac, and Indian Giant Squirrel was 1,162, 351, 169, 96, 59 and 41 respectively (Table 1).

Table 1: Number of sightings, density and abundance of large mammals through block count method for different vegetation types in Rajiv Gandhi National Park

Forest type	Sampled area	Total area	Species	Number of sightings	Number of animals	Density/sq. km for sampled area	Total number of animals for the total area
DDF	151	452	Indian Muntjac	11	15	0.1	42
			Asian Elephant	28	180	1.2	508
			Gaur	5	46	0.31	130
			Indian Giant Squirrel	8	8	0.05	22
			Hanuman Langur	13	106	0.7	299
			Spotted Deer	27	325	2.16	918
			Sambar	5	17	0.11	48
MDF	55	96	Indian Muntjac	8	9	0.16	15
			Asian Elephant	13	84	1.53	146
			Gaur	2	9	0.16	15
			Indian Giant Squirrel	6	8	0.15	14
			Hanuman Langur	4	30	0.55	52
			Spotted Deer	12	92	1.67	160
			Sambar	10	23	0.42	40
TP	89	128	Indian Muntjac	2	2	0.02	2
			Asian Elephant	6	36	0.4	51
			Gaur	5	17	0.19	24
			Indian Giant Squirrel	4	4	0.04	5
			Hanuman Langur	0	0	0	0
			Spotted Deer	13	59	0.66	84
	295	676	Sambar	4	6	0.07	8

DDF: Dry Deciduous Forest, MDF: Moist Deciduous Forest, TP: Teak Plantation

Table 2: Abundance of mammals estimated through block count method

S.no	Species	Density/sq. km	Estimated number of animals for the Park	LCL	UCL
1	Muntjac	0.1	70	59	81
2	Elephant	1.19	807	681	932
3	Gaur	0.35	239	202	277
4	Indian Giant Squirrel	0.06	40	34	47
5	Hanuman Langur	0.54	366	309	423
6	Spotted Deer	1.89	1281	1082	1480
7	Sambar	0.18	124	104	143

LCL: Lower Confidence Interval, UCL: Upper Confidence Interval

The density estimated for most of the species through this approach was low; however, the pattern clearly indicated their habitat usage pattern. Spotted Deer densities were highest followed by elephants in all the three habitats. Gaur densities were highest in the dry deciduous forest, followed by teak plantation and moist deciduous forest. Sambar utilised both teak plantation and moist deciduous forest equally (Table 1).

The results of population density and number for the Park, estimated using block count from all the three habitats, are presented in the Table 2. Even without any comparison, the number estimated by block count methods for different species of mammals were low, and for species such as Spotted Deer, Sambar, Gaur and Muntjac the density estimate by this method were substantially lower than expected.

Line transect method

The results of the line transect survey carried out during the census operation suggest that the number of sightings of Spotted Deer was greatest followed by Hanuman Langur, Indian Giant Squirrel and Elephant. However, the density estimated for Spotted Deer was the greatest followed by Hanuman Langur and Gaur. The number of sightings for both Sambar and Gaur was relatively low, but the density of Gaur was greater than the Indian Giant Squirrel. Sample size, mean group size, group density and individual density are given in Table 3. The overall pattern of the results of habitat usage by the line transect method was slightly different from that of the block count as density estimated for Spotted Deer by line transect method was highest followed by Hanuman Langur.

The comparison of the results of the block count versus line transect methods (Table 4) of census operations provide interesting insights. The density estimates of all the species by block count were an underestimation and line transect estimates appeared to be on the higher side for all the species (Table 3). The results of the differences across these methods were statistically significant (for all species $p< 0.001$, see Table 6 for z and p values).

To compare density results obtained from a long-term study of mammals (Karanth and Sunquist 1992), the distance covered, sample size, mean group size, group density and individual densities of mammals estimated by the long-term investigation are tabulated in Table 5. If the mean densities

Table 3: Sample size, mean group size, group density and individual density estimated for different species of mammals through line transect method

S.No	Species	Sample size	Mean Group size	SE	Group Density/km^2	SE	Individual Density/km^2	SE	95% CI		
									LCL	UCL	% CV
1	Indian Muntjac	38	1.19	0.12	3.95	1.05	4.7	1.34	2.08	7.32	28.43
2	Asian Elephant	56	6.54	0.87	1.82	0.38	11.92	2.95	6.14	17.7	24.73
3	Gaur	24	7.46	1.56	1.51	0.42	11.28	3.98	3.48	19.08	35.3
4	Indian Giant Squirrel	53	1.28	0.07	3.91	0.70	5.01	0.94	3.18	6.84	18.67
5	Hanuman Langur	66	7.08	0.67	2.49	0.43	17.64	3.47	10.84	24.43	19.66
6	Spotted deer	106	8.58	1.15	6.39	0.81	54.86	10.16	34.95	74.77	18.52
7	Sambar	29	2.17	0.21	1.64	0.41	3.55	0.95	1.69	5.42	26.74
8	Wild Pig	22	2.82	0.57	1.47	0.3	4.15	1.2	1.79	6.51	29.02

SE = Standard Error, LCL: Lower Confidence Interval, UCL: Upper Confidence Interval, %CV: Coefficient of Variation

Table 4: Density and total number estimated for block and line transect method during the census operation.

S. No	Species	Line transect Mean Density/km^2	 Total number	Block count Mean Density/km^2	 Total number
1	Indian Muntjac	04.7	3,050	0.1	70
2	Asian Elephant	11.92	7,736	1.19	807
3	Gaur	11.28	7,321	0.35	239
4	Hanuman Langur	17.64	11,448	0.54	366
5	Spotted Deer	54.86	35,604	1.89	1,281
6	Sambar	03.55	2,304	0.18	124

estimated by the line transect method during the census and the long-term study (Karanth and Sunquist 1992) are subjected to a statistical test for their significance, then the results will be as follows. Mean densities of Spotted Deer, sambar, gaur and muntjac were not statistically significant (see Table 6 for z and p values). There were clear differences for mean density estimates of elephant ($z = 1.98$, $p > 0.05$) and langur ($z = 3.1$, $p < 0.001$).

The comparison of the results of the block count and long-term study by the line transect method show that for elephants, the differences of densities' estimates across these two methods were not statistically significant ($z = 1.73$, $p > 0.05$), but for all other species the differences were highly significant ($p < 0.001$, see Table 6 for z and p values).

DISCUSSION

As seen from the results, for species such as Spotted Deer, Sambar, Gaur, and Muntjac, the block count method underestimates their number considerably. Without any information on the actual area of habitat used by different species of mammals, the density estimates cannot be extrapolated to the entire Park. If this is the situation, the total number projected by block count would be even lower, and clearly this is an underestimate for most species.

For species such as Sambar, Spotted Deer, Gaur and Muntjac, both long-term and short-term annual census based line transects could be an appropriate method for estimating their number. However, the estimated percentage of coefficient of variance (%CV) for most of the species during the census operation was high; the values were above 20% and ranged up to 35%. The values may be influenced by the sample sizes obtained for some of these species and more efforts are needed to increase these sample sizes. Increase in the sample sizes may decrease the %CV to an acceptable level (say = 15%) and this can be evident from the results of the line transects based on long-term population monitoring (see Tables 3 and 5 for sample size and %CV values).

For elephants, short-term or census-based line transect methods may not be an appropriate method. This could be due to their seasonal movement and this constraint may to some extent be applicable for the gaur too. For elephants, using census operation results (of line transect method), when the density was extrapolated to the entire area, the total number for the Park was about 7,736. The total elephant population estimated for 24 forest divisions in southern India is only about 9,950 elephants (Sukumar *et al.* 2006). Hence, the density estimated for the sampled area should not be extrapolated to the entire area. One of the reasons for the higher density estimate could be due to the number of sightings during the particular period of the census being very high. Karanth and Sunquist (1992) encountered 46 groups of elephants in a 462 km transect survey, whereas in the census operation, the number of groups sighted for the 250 km transect was 57. If the census operation was conducted in higher density areas or seasons, the density of elephants estimated for the survey would not be a true representation for the entire region or seasons.

Table 5: Sample size, mean group size, group density and individual density estimated for Rajiv Gandhi National Park by Karanth & Sunquist (1992)

S. no	Species	Sample size	Mean group	Group density	Individual density	95% CI LCL	 UCL	 % CV
1	Muntjac	92	1.15	3.64	4.2	2.8	5.6	17
2	Elephant	56	3.59	0.92	3.3	1.9	4.7	22
3	Gaur	67	6.99	1.37	9.6	5.9	13.2	20
4	Langur	240	5.73	4.16	28.8	16.3	31.4	16
5	Spotted deer	376	6.27	8.08	50.6	38.5	62.7	12
6	Sambar	94	1.7	3.23	5.5	3.7	7.4	17

Density is expressed in sq. km, LCL: Lower Confidence Interval, UCL: Upper Confidence Interval, %CV: Coefficient of Variation

Table 6: Comparisons of the results of different methods of population estimation of large mammals by census and a long term study at Rajiv Gandhi National Park

	Block count	Line transect			Line transect	Long term study			Block count	Long term study		
Species	Mean density/km^2 (SE)	Mean density/km^2 (SE)	z value	p value	Mean density/km^2 (SE)	Mean density/km^2 (SE)	z value	p value	Mean density/km^2 (SE)	Mean density/km^2 (SE)	z value	p value
Muntjac	0.1 (0.01)	4.7 (1.34)	4.0	<0.001	4.7 (1.34)	4.2 (1.4)	0.2	> 0.05	0.1 (0.01)	4.2 (1.4)	3.5	<0.001
Elephant	1.19 (0.09)	11.92 (2.95)	6.2	<0.001	11.92 (2.95)	3.3 (1.4)	2.0	<0.001	1.19 (0.09)	3.3 (1.4)	1.7	> 0.05
Gaur	0.35 (0.03)	11.28 (3.98)	5.4	<0.001	11.28 (3.98)	9.6 (3.6)	0.2	> 0.05	0.35 (0.03)	9.6 (3.6)	4.8	<0.001
Langur	0.54 (0.04)	17.64 (3.47)	9.2	<0.001	17.64 (3.47)	28.8 (9.1)	3.1	<0.001	0.54 (0.04)	28.8 (9.1)	9.1	<0.001
Spotted deer	1.89 (0.15)	54.86 (10.16)	16.5	<0.001	54.86 (10.16)	50.6 (12.1)	0.2	> 0.05	1.89 (0.15)	50.6 (12.1)	13.9	<0.001
Sambar	0.18 (0.01)	3.55 (0.95)	3.4	<0.001	3.55 (0.95)	5.5 (1.9)	1.2	> 0.05	0.18 (0.01)	5.5 (1.9)	3.8	<0.001

The other reason for higher density estimates by census than by the line transect method could be due to the influence of mean group size. The mean group size estimated by Karanth and Sunquist (1992) for the elephant was 3.6, and the census estimate was 6.5. However, the group density estimate by Karanth and Sunquist (1992) was lower than that of the census operation. The higher group density and mean group size would have contributed to the higher density of elephants estimated by the census operation. Information connected to the deviation or error associated with mean group size was not available for the Karanth and Sunquist (1992) study and it was not possible to look at the statistical significance across the mean group sizes of these two approaches. Karanth and Sunquist (1992) estimated a density of 3.3 (95% CI: 1.9-4.7) and felt that the density may have been an overestimate and the actual density may be close to the lower confidence limit. This impression may match with the overall density estimate of the block count method of census operation.

Based on this experience, it can be concluded that for species that are alert, or shy in nature, active more during early morning or late evenings, small in size or found in low density, the block count method is not an appropriate method. For elephants, block count method could be an appropriate method. If a population estimate for elephants is to be made, it should be done through long-term line transect method while the block count method may provide reasonable estimates for census operation. Depending on the season of the operation, short-term transect method may over or underestimate the number of the species.

The major drawback of the census operation is that during the operation, particularly for the line transect method, the perpendicular distance measurements were arrived at based on visual estimations, and no range finder or other instruments were used. Distance measurements appeared to be more sensitive to error for elephant and arboreal species like Hanuman Langur. Fixing the geometrical centre of the group for distance measurements may be difficult for these two species and the absence of range finders may further complicate this issue. The services of untrained personnel and the absence of these instruments could have led to the underestimation of the sampled area and overestimation of the animal numbers.

It should be noted that long-term population studies cover only less than 1% of the total population size or geographical distribution area of most of the species and these investigations are restricted only to certain periods of time. Except for one investigation of long-term population monitoring of mammals in Mudumalai (CES 2007), no study has been carried out in more than three years. Therefore, the regular census programs may have some scope for understanding fluctuations in population numbers of most of the species. If census results are processed properly, they also have the advantage of providing details of the habitat utilisation patterns for most of the species.

The options available to the wildlife managers are to critically review the outcome of the earlier census operations and based on the findings improve the quality of future census programs. If these reviews disqualify census operations altogether, resource that have been earmarked for census operation only should be invested into long-term investigations as resource used for short-term census program can be meaningfully used for the long-term studies. With the given manpower and resource limitation, the census operation has shown results comparable with those of long-term study carried out in a region where the biomass of ungulate is very high (Karanth and Sunquist 1992). This may indicate two basic facts: well-planned census operations with trained personnel and the knowledge gained from the experts in the field may improve the quality of the results and provide reasonably acceptable numbers. More specifically, the outcome of the exercise (some of the results matching with long-term investigation) may be due to a chance factor and more rigorous evaluations have to be carried out for meaningful conclusions. The findings also suggest that future census operations should consider carrying out the exercise in regions where long-term population investigations are on and where the method adopted for both these approaches are compatible.

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Our former colleague Dr. Arun Venkatraman provided valuable support while designing and executing the program. The census data was reanalysed with the support provided by Archana Prasad of Centre for Ecological Sciences, and Santanu Datta of the Asian Nature Conservation Foundation (ANCF) provided GIS support. Dr. Renee M. Borges and Dr. N.V. Joshi (Centre for Ecological Sciences) have gone through the earlier version of the document and were motivation for this publication.

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J.C. Daniel

(1927-2011)

Obituary

J.C. Daniel

(1927-2011)

Mr. Jivanayakam Cyril Daniel was born on July 9, 1927, in Nagerkdil in Tamil Nadu. Mr. Jivanayakam – his father – was a famous educationist of Keraia (Travancore at that time). Mr. Daniel, or JC as he was fondly called by his colleagues, joined BNHS in 1950 at a young age of 23 as Research Assistant in the Collection Department of the Society with an M.Sc. degree in Zoology. Save for a break of five years, from 1955 to 1960, when he worked as a curator at the Natural History Museum, Darjeeling, he devoted his entire life to the Society, first as Director (called Curator at that time) from 1960 till his retirement in 1991, and later in various capacities as Honorary Secretary and Vice President. After a brief illness, he expired on August 23, 2011, at the age of 84.

Mr. Daniel was a complete naturalist, interested in all aspects of natural history, but his forte was reptiles. His most famous book THE BOOK OF INDIAN REPTILES, first published in 1983, was updated and reprinted twice as THE BOOK OF INDIAN REPTILES AND AMPHIBIANS, since 2002. He edited and revised six books, and contributed chapters/sections to a few more. He was one of the editors of the *Journal of the Bombay Natural History Society* from 1965, and Executive Editor from 1989 till 2003. He conceived and designed *Hornbill*, the popular magazine of the Society in 1976 and remained its Editor till 2004. He guided seven M.Sc. and ten Ph.D. students in Field Ornithology, Mammalogy and Herpetology.

Since 1953, when his short note on the tadpole of *Rana leithii* Boul. was published in the *JBNHS* (51: 512-514), he published 25 papers in Herpetology, 8 papers in Mammalogy, 9 in Ornithology and 8 short notes, mainly in the *JBNHS*. Over a career of nearly 60 years the number of his research publications may not be impressive, but they had a great influence on the trend of vertebrate ecological studies in India. Mr. Daniel's contribution to the status surveys of species like Indian Wild Buffalo, Blackbuck, Tiger, Nilgiri Tahr, Saltwater Crocodile, Asian Elephant and Golden Gecko will be remembered for long, as these surveys generated baseline information for vital threatened species. His questionnaire survey on Tiger in 1968-69 resulted in an analysis of the status of this species and drew attention to the need for immediate conservation measures. These results were presented in the IUCN Assembly in 1969 and published in 1970 in *JBNHS* (67: 227-234), and greatly influenced the establishment of Project Tiger a few years later. His paper on the rediscovery of Golden Gecko *Calodactylodes aureus* in the Tirupathi Hills of Andhra Pradesh resulted in the establishment of a national park in the area. From 1980 to 1991, along with Dr. Sálim Ali, he guided four major projects of the Society. These large projects funded by U.S. Fish & Wildlife Service resulted in total transformation of research and conservation activities in BNHS, as a large number of field scientists were recruited, many working for their M.Sc. and Ph.D. degree under Mr. Daniel. Many of these scientists are now influencing the conservation movement of India.

Mr. Daniel was a recipient of many awards, starting with Sir Peter Scott Award for Conservation in 1988, Indira Gandhi Paryavaran Award in 1997, Sanctuary-Amro Bank, Millennium Lifetime Service to Conservation Award in 2000, and Distinguished Service Award from the Society for Conservation Biology in 2007. He was also a member of various government committees on wildlife and conservation.

Mr. Daniel's major achievements are not his research papers and awards, but his legion of students and colleagues that he was able to influence. For almost 50 years, he was the doyen among the naturalists of India with a vast knowledge of India's wildlife. Mr. Daniel's influence will be felt for many years after his demise, as many of his students are continuing the work that he started as a young apprentice in BNHS in 1950.

Asad R. Rahmani

REVIEWS

1. BIRDS OF THE INDIAN SUBCONTINENT – A FIELD GUIDE. By Ranjit Manakadan, J.C. Daniel and Nikhil Bhopale. Illustrations by John Henry Dick. Published by Bombay Natural History Society/Oxford University Press. 2011. 409 pp. Size: 14 cm x 21.8 cm. Price: Rs. 550/-. Hardback.

This new avatar of A PICTORIAL GUIDE TO THE BIRDS OF THE INDIAN SUBCONTINENT first published in 1983 by the Bombay Natural History Society (BNHS) as part of their centenary celebrations looks compact and handy, and has a real nice feel about it. Being the first ever attempt to illustrate (nearly) all the bird species found in the Subcontinent in one volume, it is a real shame that the Society did not cash in on the golden opportunity to publish the book in the present format earlier, which would have benefited birdwatchers all over the country. But it is always better late than never.

The text part of the book includes brief accounts, family-wise, as in the PICTORIAL GUIDE (but now following the sequence as in the BIRDS OF SOUTH ASIA – THE RIPLEY GUIDE by Rasmussen and Anderton with a cross reference to the plates. This is followed by the plates – 112 in all, covering 1,251 species. The text, in addition, describes about 100 species (mostly based on recent splits).

The text facing the plates contains the reference number in THE HANDBOOK OF BIRDS OF INDIA AND PAKISTAN by Sálim Ali and S. Dillon Ripley, the common English name (with alternate names in parentheses) and the scientific name. The common names are based on the recommendations of Manakadan and Pittie (2001) or THE RIPLEY GUIDE, while the alternative names are those that are used in other recent field guides. The residential status (using abbreviations) and the size of the bird (both in cm, as well as based on comparison with some common and familiar bird as a standard) are given. This is followed by a brief reference to the species' distribution in the Subcontinent, often including individual records in case of uncommon birds. The ID section is crisp and contains essential tips to identify the bird and variations in the plumage. Calls are described for certain groups of birds, but not all the species. Wherever applicable, a brief note mentions the changes in taxonomy and describes recent splits, mainly based on THE RIPLEY GUIDE. There is also a cross reference to the species account in THE BOOK OF INDIAN BIRDS (13th Edition), and a mention in case a particular species' occurrence in the region is treated as hypothetical by THE RIPLEY GUIDE.

Other than this, the book also contains a brief Preface that traces the evolution of illustrated bird guides in the Indian subcontinent, a brief biographical sketch of Dr. Sálim Ali and Dr. S. Dillon Ripley, the two doyens of Indian Ornithology; a brief introduction to the book and its various features, explanations and abbreviations, a glossary of technical terms used in the book, diagrams depicting bird topography and exhaustive indices (plate-wise, common names and scientific names). The book has also used 53 vintage paintings of birds from older publications and has a colour map of the Subcontinent. The paintings are used as fillers so that the plates always appear on the left side with the text facing it.

I wish to make the following observations and comments on this publication:

The title of the book could have been different as we now have two versions of the book – the one by Grimmett and Inskipp also bears the same title (but different sub-titles), and this could cause some amount of confusion.

Compared with the PICTORIAL GUIDE (1st Edition), I find the illustrations less cluttered and more sober in colours. Quite a few illustrations have been 'touched-up' to enhance accuracy. However, I still felt plates 93 and 94 that deal with warblers (19 and 22 species respectively), for instance, could have had bigger illustrations as the differences between the species are more subtle and need to be emphasised to enable easier identification in the field, even if this means more plates, more bulk and higher cost of production.

The uniform usage of white background for the plates is easier on the eye, though in some instances where the species has, for instance, white coloration on its outer tail feathers, these are not always easily noticeable (example: Pl. 101: spp. nos. 4, 6, 7, 8, 12, 13, 15, 16, 17).

There is no indication of the scale of the birds in the plates and so the result can be somewhat misleading, especially for beginners: e.g., Plate 51: Rollers and Trogons; Plate 60: Lineated and Great Barbets; and Plate 34: Great Indian Bustard and Sarus Crane.

There is still some scope for improving the details in the illustration, e.g., Plate 70: White-browed Bulbul shows much darker underparts than in real life or as mentioned in the text. Also, in the case of migrant waders and warblers, variations in the summer and winter plumages are not shown in the plates. The text is also silent about some of these variations.

In the arrangement of plates, at least I could come across two instances where individual species got isolated from their family or genera. Drongo Cuckoo finds its place on Plate 110 along with drongos rather than with the cuckoos (Plates 51-52) and there is not even a mention of the species in the cuckoo section! The other instance is that of the Ashy-headed Laughing Thrush of Sri Lanka (Plate 87), which is isolated from the other laughing thrushes and is placed along with babblers.

I also have a comment on the illustration of the Indian Pygmy Woodpecker (a filler diagram appearing on page 201) where the pair is shown perched cross-wise (like passerines) on twigs, quite close to the ground, mobbing a snake. These birds, in my experience, are usually found foraging on tall trees and closer to the canopy and mid-canopy strata. This diagram therefore is somewhat misleading.

Though the text is brief, it appears to be quite adequate in most cases. Yet, I find that some most recent information had been omitted as in the case of the Lesser Grey-headed Fish-eagle (p. 63) and the Grey-headed Lapwing (p. 117) where there have been several recent sightings outside the range that is mentioned in the book.

While the section on ID has been dealt in fair amount of detail and without too much of cluttering of data, making it user-friendly, it may look too simplistic in the case of difficult groups, such as warblers, pipits, larks, etc. To identify birds in these groups, one needs details such as the jizz, habits, etc., which are lacking in this work. Again in the bird groups, such as raptors, details on the ID are kept to the bare minimum with information on intermediate plumages and colour phases omitted. This is bound to cause problems for inexperienced birdwatchers.

Calls are described only for select groups of birds like the owls, nightjars, some warblers, barbets, some cuckoos, doves, pheasants, partridges and quails, pipits and bush-larks. In some of the species where calls are perhaps the first clue to the presence of these birds in their respective habitats (e.g., Spotted or Puff-throated Babbler, the whistling thrushes, Indian Pitta, Coucal), lack of this vital information is bound to cause some amount of disappointment. Indeed, to make identification more reliable, I often depend not only on the physical features of the birds, but also its micro-habitat, calls, characteristic habits, etc. I do hope the future edition would look into these aspects as well so that the text is well-balanced and more comprehensive.

An indication of the conservation status of the species (in terms of the various conservation categories) would have been useful and alerted the users of this book to collect more details about the species for conservation purposes. Lists of organizations involved in bird conservation, useful resources such as good birding sites, IBAs, websites, books, etc., would have been welcome features to novices to birdwatching and birders visiting the Subcontinent.

Overall, I find this publication a very useful addition to the bird literature of the Subcontinent and I hope more birdwatchers would use it in the field because of its compact size. Besides, the price-tag is very attractive and I feel this book is real value for money.

■ V. SANTHARAM

2. UNGULATE TAXONOMY by Colin Groves and Peter Grubb. Published by The Johns Hopkins University Press, Baltimore, USA, 2011. 317 pp. Size: 26 cm x 18 cm. Price not mentioned. Hardback.

Ungulates or hoofed animals, belonging to Orders Artiodactyla and Perissodactyla, are some of the most visible animals of any landscape. They are generally large, mobile, most of them live in big herds, and are good to eat, hence extensively hunted. Some of them have been domesticated for thousands of years from their wild ancestors. For example, goat *Capra hircus* Linnaeus 1758 from wild *Capra aegagrus* Erxleben 1777, water buffalo *Bubalus bubalis* (Linnaeus 1758) from *Bubalus arnee* (Keer 1792), and pig *Sus domesticus* Erxleben 1777 from *Sus scrofa* Linnaeus 1758. These domestic ungulates have influenced civilizations and played a major role in the dispersal of human beings. Can one imagine life without the dromedary camel *Camelus dromedarius* Linnaeus 1758, in the Arabian Desert? Or travel in the remote corners of the Andes without the llama *Lama glama* (Linnaeus 1758) that originated from the wild *Lama guanicoe* (Müller 1776).

Being large and familiar does not mean that the taxonomy of ungulates is well-understood. A few taxa are extremely complex and a challenge to taxonomists to unravel their phylogeny. The first major work on ungulate taxonomy was published by Pallas in 1766, 1767-77, and 1811, through his collection trip to the Russian Empire and also based on descriptions by others. The next major contributor was Alfonse Desmarest in 1822, who described new species from the collections of French explorers, deposited in the Paris Museum, and also confiscated from other museums during the brief colonisation of neighbouring countries by Napoleon Bonaparte. By the end of the 19th century, the British Museum (Natural History) had a huge collection of specimens from Asia, Africa and the Americas. Ungulate taxonomy was described by Richard Lydekker in 1913, 1914, and 1915 as a Catalogue Series from the specimens present in the British Museum (Natural History). Till this book came out in 2011, for almost 100 years there was no serious revision of ungulate taxonomy, although Colin P. Groves had published numerous research papers on this subject, starting from 1967.

The first author, whom I know through correspondence, has more than 45 years experience in ungulate distribution, morphology, behaviour and taxonomy. He has published nearly 80 papers on taxonomy as first author, besides an equal number as second or third co-author. The second author was also a leading ungulate taxonomist, until his death in December 2006. This book is the seminal work of these two great ungulate taxonomists.

Species-by-species accounts incorporate new genetic and morphological information as well as the authors' own observations and measurements from various museums. I am interested in *Gazella* as I have done some studies on Chinkara *Gazella bennettii*. The taxonomy of this genus is extremely complex and controversial. There are three clades in this genus: the *G. bennettii* group, the *G. subgutturosa* group, and a *G. dorcas/G. spekei/G. gazella* group. Within the Chinkara *G. bennettii* group, this book describes five subspecies or types. Two taxa are found in Iran and Pakistan: Western Jebeer *Gazella shikarii* Groves 1993, and Eastern Jebeer *G fuscifrons* Blanford 1873, while three taxa are found in India and Pakistan. They are Gujarat Chinkara *G. christyi* Blyth, 1842, found in Gujarat, Thar Desert, and probably the rest of Rajasthan; Deccan Chinkara *G. bennettii* (Sykes 1831), found in the Deccan Plateau and the Ganges Valley; and Salt Range Gazelle *G. salinarum* Groves 2003, found from Salt Range eastwards to Delhi.

There are some interesting taxonomic discoveries described in this book. For example, the Arabian Tahr, till recently known as *Hemitragus jayakari* Thomas 1894 and described from Oman, was considered related to Himalayan Tahr *Hemitragus jemlahicus* (Hamilton-Smith 1827). It is now placed in genus *Ammotragus* and related to *Ammotragus lervia* Pallas 1777, a mysterious species restricted to the mountain ranges in the Sahara and the Meghreb. The endemic Nilgiri Tahr, first described as *Kemas hylocrius* in 1837 by Ogilby, but subsequently placed in genus *Hemitragus* (Prater 1980), now has its own genus *Nilgiritragus* Ropiquet & Hussanin 2005, and surprisingly, it is more closely related to *Ovis*, than to the other species of tahr.

The book also lists some of the critically endangered ungulate species of the world, which is a sad reflection on the activities of human beings as most of these ungulates are dying due to hunting, habitat destruction, and in some cases purely due to conservation neglect. For example, Javan Rhinoceros *Rhinoceros sondaicus* is the second rarest of all large mammals in the world with less than 60 surviving. *Gazella acaciae* may have only 20 individuals left in total, and *G. arabica* has not been seen since its original description, 180 years ago, while *G. bilkis* may be extinct, or nearly so, because of overhunting. Schomburgk's Deer *Rucervus schomburgki* described by Blyth in 1863, of which BNHS has a mounted head, is probably extinct. It was known only from the swamps of Central Thailand. Its relative, Swamp Deer *Rucervus duvaucelii*, occurring in three subspecies, is doing fine, thanks to conservation efforts made by India and Nepal.

Sadly, the status of wild relatives of domestic animals, which are our most valuable genetic resource, is nothing to be proud of. For example, *Bos sauveli* or Kouprey of Thailand, described in 1937, is probably extinct due to overhunting. It was known to hybridise with Banteng *Bos javanicus*, which itself is threatened with extinction. Bali cattle and the feral Australian Banteng population are derived from the wild Banteng. A valuable genetic resource, which we could have used to improve the Bali cattle, has been lost with the extinction of Kouprey. Similarly, another important potential genetic resource, *Bubalus mindorensis* Heude 1888 or Tamaraw, also known as Philippine Dwarf Buffalo, is reduced to less than 300 individuals. Closer home, we have the Asian Wild Buffalo *Bubalus arnee*, with four subspecies. *Bubalus arnee arnee* (Keer 1792) was found from the north-east Nepal Terai, and formerly from the Sundarbans south-west to Madhya Pradesh and Andhra Pradesh. It now survives in small numbers in Nepal, and an ecologically dead population in central India (with only one known adult female). Despite the fact that it is a direct ancestor of our domestic buffalo and an extremely valuable genetic resource, practically no attention is given by the Indian Government to protect the wild population in central India. Fortunately, recent genetic studies by Kumar *et al.* (2007) on the Wild Buffalo of Kosi-Tapu in Nepal show very little gene flow from domestic to wild animals, and rather more gene flow the other way. This gives us hope that if subspecies *arnee* disappears from central India, we might be able to get the pure wild strain from Nepal to reintroduce it in India. The second subspecies *Bubalus arnee fulvus* (Blanford 1891) is in slightly better condition in Assam and the lower reaches of Bhutan (Choudhury 2011), but may be extinct in Bangladesh where it was known from Chittagong Hills. The third subspecies *B. arnee theerapati* Groves 1996, still occurs in Thailand and Cambodia. The fourth subspecies, which some consider feral, termed *B. b. migona* Deraniyagala 1952, is located in Yala National Park, Sri Lanka, and is now threatened by interbreeding with domestic buffalo.

This is a serious and technical book, not for the general reader who has grown up seeing glossy coffee-table books of the African savanna ungulates, but a must for any library and museum. I agree with the blurb on the last page of the book "A well-reasoned synthesis, UNGULATE TAXONOMY will be a defining volume for years to come."

■ ASAD R. RAHMANI

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3. CONSERVATION REFUGEES: THE HUNDRED-YEAR CONFLICT BETWEEN GLOBAL CONSERVATION AND NATIVE PEOPLES by Mark Dowie. Published by Massachusetts Institute of Technology Press, Massachusetts, USA, 2009. 339 pp. Size: 23.5 cm x 15.5 cm. Price not mentioned. Hardback.

This is a remarkable, thought-provoking and controversial book from an investigative journalist, well-known for his strong views on the rights of local communities. I must say that this book should be read by all leading conservationists, human rights activists, conservation NGOs, decision makers and anyone who is interested in the long-term security of wildlife and wild places. It is now recognized all over the world that without involving local communities and using their traditional knowledge and wisdom, we cannot save our protected areas, and particularly large wide-ranging landscape species. As modern human beings are the major problem for PAs and species conservation, we cannot have a solution without involving them.

Like many other modern concepts (and problems), the idea of establishing large protected areas was started in the USA by the creation of Yellowstone National Park in 1872. Since then, more than one hundred thousand PAs have been established in the world. While half of them were established in remote, uninhabited, or thinly inhabited areas, the rest had indigenous people living or regularly using them for hundreds of years. In the northern countries, local communities or inhabitants were incorporated into the PAs, but in less developed countries of Asia, Africa and Latin America, local communities were displaced in the interest of conservation. Now they are fighting back, leading to huge conflicts. Sadly, the worst sufferers in these people-PA conflicts are the species or ecosystems for which these PAs were established in the first place. This is particularly acute where local people do not benefit from PAs. With no political support to wildlife conservation, particularly in democracies, and increasing demands of people and industries, the future of the present concept of PAs looks bleak.

The book is divided in 19 major chapters, covering examples of PA-tribal conflicts from all over the world. The language is simple, free of jargon, except for the large number of abbreviations dotted all over the book. The author is particularly harsh on large international conservation organizations or BINGOs (Big International NGOs) such as WWF, IUCN, Conservation International, Wildlife Conservation Society and TNC. The text in many places shows his prejudice rather than an objective assessment. We have to accept that BINGOs and national and regional conservation organizations have played a major role in arresting the decline of many threatened species. Admittedly, we could have achieved many more conservation successes by greater involvement and benefit to indigenous communities, but priorities are now changing. People's involvement in conservation is now in the mandate of all major dynamic NGOs such as BirdLife International, whose motive is "For Birds, For People".

The journalistic streak of the author is seen throughout the book. In many places, the language and tone is of an activist pamphleteer, not an unbiased serious writer. Although Mark Dowie extensively quotes writer-thinkers like Ramachandran Guha and Ashish Kothari, particularly on Indian issues, many quotes have been taken out of context to fit his views. He is also wrong in many places. I quote only Indian cases. For instance, it is wrong to say that "about eight thousand tribal people and low-caste farmers living in the Kuno area ... were summarily uprooted from the rich farmlands ... for a pride of six imported Asiatic lions." I have been to Kuno-Palpur many times in the 1980s. First of all, the people "uprooted" were not all tribal and low caste, secondly they were not cultivating "rich farmland". Most of them were living in extreme poverty in remote villages, with very little cultivable land, with no facilities like potable water, electricity, proper schools and hospitals. The roads were so bad that once I had to return halfway, without even reaching Palpur. It is also wrong to sensationalise that "for a pride of six imported Asiatic lions", 8,000 poor "tribal people" were uprooted. Reintroduction of the Asiatic Lion into Kuno-Palpur was a well-thought out scheme, and the "tribal people" were given good compensation, cultivable land and basic facilities that they did not have in their remote forest villages. Kuno-Palpur is one good example of properly planned relocation and rehabilitation where now the villagers have good cultivated land, accessible roads, schools, hospitals and modern connectivity. Unfortunately, the "six imported Asiatic lions" have not reached Kuno-Palpur Sanctuary due to petty politics in Gujarat, but that is a different story.

The book frequently glorifies the "sustainable lifestyle of tribal and indigenous communities". I wish this were true, even partially. Increase in human population, decrease of forest cover and demands of market forces have upturned these so-called sustainable lifestyles. What was sustainable a hundred years ago, with a small tribal community with thousands of square kilometres of forest/grassland around them to exploit, is no more sustainable. If all tribals really live sustainably, why do we have barren hillsides for miles and miles in the tribal districts of western Madhya Pradesh or the Khandesh area of Maharashtra? Why is it that practically no large ungulate survives in the tribal districts of northern Gujarat? Isn't sustainable hunting beneficial for tribals so they can hunt throughout their life and for generations without exterminating wildlife? Hunting is so intense and unsustainable that even sighting a squirrel is difficult in some of these tribal inhabited areas in Gujarat. If tribal wisdom teaches us to live sustainably, then why have the tribals of Nicobar started using snares to catch egg-laying Nicobar Megapode, and shoot birds by airguns. Why can't they harvest a few eggs from the Megapode nest mounds and spare the adult birds so they can lay more eggs. Even in our backyard poultry, we do not kill egg-laying birds.

Admittedly, the book gives a one-sided view and glorifies the role of tribal communities and their so-called sustainable lifestyle. Nonetheless, it is an interesting book and should be read by all those who are interested in wildlife conservation. We may not agree with every viewpoint of Mark Dowie, but we cannot afford to ignore him either. That is why I say, it is a remarkable book because it forces us to re-think our conservation paradigm.

■ ASAD R. RAHMANI

4. THE STORY OF ASIA'S ELEPHANTS by Raman Sukumar. Published by The Marg Foundation, 2011. 339 pp. Size: 18.7 cm x 22.5 cm. Price: Rs. 3,500/-. Hardback.

The Asian Elephant is again at the crossroads of its survival struggle against man. Of the three species of the elephant family that inhabited the earth, only two remain: the Asian Elephant (*Elephas maximus*) and African Elephant (*Loxodonta africana*). The tale of the extinction of the mammoth, brought about by climate change and aided by persecution by man, is an ominous sign on what could befall the two extant species if elephant habitats continue to be destroyed and the animals persecuted. Of the two extant species, the situation of the Asian Elephant is more at risk as its populations are now confined to the few remaining forests, and even these last tracts are facing huge pressures due to the increasing human population.

Once widely spread from the Euphrates through the Indian subcontinent, Indo-China, southern China and SE Asia, the Asian Elephant now occurs in pockets in some of its former ranges numbering around 40 to 50 thousand animals, with more than 50% of the population in India. Elephant has always fascinated humankind and no other wild animal has had such a close love-hate relationship with man. Hinduism venerated it to the status of a god (Lord Ganesha) – one reason why there are fairly still so many elephants left in India. Used for war, for carrying deities and rajas, in forestry operations, to entertain in circuses, for begging and also hunted for ivory, their association with humans has a long history.

Dr. Raman Sukumar is India's most well-known elephant biologist and an authority on the Asian Elephant worldwide. A Professor at the Centre for Ecological Studies, Indian Institute of Science, he has his own set-up, the Asian Nature Conservation Foundation, which has undertaken a number of significant projects on elephants and other wildlife. Dr. Sukumar has three 'bestsellers' on elephants to his credit. The first, THE ASIAN ELEPHANT: ECOLOGY AND MANAGEMENT (1989), is a scientific treatise of the species based largely on his doctoral work in southern India (the Biligirirangans) investigating its ecology and interaction with man. This was followed by ELEPHANT DAYS AND NIGHTS (1994), a popular account of his initiation into elephant studies and his doctoral work. This publication, besides throwing light on his work and findings on the Asian Elephant makes delightful reading, revealing Dr. Sukumar's talent as a gifted writer. The third, THE LIVING ELEPHANTS: EVOLUTIONARY ECOLOGY, BEHAVIOUR AND CONSERVATION, covered both the Asian and African elephants, dealing with their evolution, behaviour, ecology, their interactions with humans, and their conservation and management. This was regarded as his *magnum opus* till date.

The new publication, a highly illustrated book, primarily provides a historical account of the Asian Elephant, tracing its association with man, and impacts/influences on the culture, religion, wars and lifestyles of people in India and in the rest of its distributional range. This is no doubt another significant publication on the Asian Elephant by Dr. Sukumar. Even from a casual perusal of the publication, one quickly realizes it is a high quality publication – from the design and layout of the book, quality of the illustrations, coverage, authoritative text and its readability. Reading the book, one not only gets to know more on the cultural history of the Asian Elephant from ancient to contemporary times, but gets one's knowledge of history (and archaeology) brushed up, as there is a lot of discussion on wars and kingdoms in which elephants figured.

All said, I would have preferred a smaller and more compact book. Size and bulk are becoming a liability in today's world as mankind moves into flats and smaller dwellings, with books of various disciplines flooding the market, and in our attempts towards a more eco-friendly world. This could have been achieved with more judicious use of space by reducing the size of the images where large-sized illustrations seem unnecessary (e.g., see pages 24 and 67) and with crisp page formatting (e.g., see pages 70-71). The electronic media, which is slowly taking over hard copy options, can be expected to be the norm in the generations to come. But I guess, till then, authors will cherish a publication in a physical form, for its visual grandeur and the pleasure in just possessing it and while gifting it to someone.

The last chapter is on the ecology and conservation of the Asian Elephant, which seems out of sync with the other chapters, as also with the introductory write-ups on evolution of the elephant family. These write-ups may be informative for a person who is new to elephants, but ideally, I feel that the publication should have restricted its coverage to the relationship of man with elephants, and more so since the author has other books that cover elephant ecology, behaviour and conservation. This is not to say in any way that it is not a great book in its present form – all elephant researchers must necessarily possess a copy.

■ RANJIT MANAKADAN

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MISCELLANEOUS NOTES

1. RESETTLEMENT AND NESTING OF STREAK-THROATED SWALLOW *HIRUNDO FLUVICOLA* BLYTH, 1855

Madhur Mohan Ranga[1], Vijay Kumar Koli[2,3] and Chhaya Bhatnagar[2,4]

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Streak-throated Swallow *Hirundo fluvicola* is a member of Family Hirundinidae, and resident to India. A highly gregarious bird it usually nests in close proximity of water with other swallows (Ali and Ripley 2001). Except its distribution (Grimmett *et al.* 1999; Ali and Ripley 2001), no information is available from literature about its ecological and ethological aspects.

A colony of Streak-throated Swallow at the Government College Malpura, Tonk (Rajasthan), was destroyed by the College Estate Wing while renovating the college building on October 15, 2010. The birds did not abandon the destructed nest site, instead after four days they started rebuilding the nests at the same site. The nests were built on the underside of the roof of the building 9 m from the ground. The colony was rebuilt in four months (Eds: photographic evidence provided); for this the birds collected mud from the waterline of a pond, about 400 m south-east. Blobs of mud were deposited on the building wall to make the first layer of the nest. The birds took about 15 to 20 days to deposit a single layer of mud, slowly constructing spacious chambers in each nest. After completing the nest, a tunnel of mud was added to the side of each nest. A total of 259 nests were counted in the colony. Ten incomplete nests in the colony were encroached by *Passer domesticus*.

Destruction of one row of nests could not keep the birds away from the nesting site. Instead, they made two rows of nests at the same site. The estate wing of the College cleans the walls every year, and the birds return every year to colonize the same site.

Nest building material of birds has been studied by many like Dewar (1909), Ali (1931), Mathew (1972), Davis (1973), Clark and Mason (1985), Fauth *et al.* (1991), Sharma (1991), and Brouwer and Komdeur (2004). Resettlement of Streak-throated Swallow at the same site might be influenced by proximity of agriculture lands and waterbodies. Selection of nest site is an important task in colonial breeding (Frederick and Collopy 1989). Birds usually prefer their nesting sites within the foraging site so as to reduce the number of trips to the nest. Closer feeding sites also help in increased vigilance of the nest and minimise chances of predation of eggs and nestlings (Ishtiaq *et al.* 2004). Korol and Hutto (1984) also showed the significance of different habitat around nesting sites of the birds. Phenomenon of resettlement has also been observed in weaver birds (Alexandar and Pushparaj 2010). Further study is required on the social organization and ethological aspects of this species, which will help to determine its management.

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2. NILGIRI PIPIT *ANTHUS NILGHIRIENSIS* FEEDING IN FLOWING WATER

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Nilgiri Pipit *Anthus nilghiriensis* is endemic to grasslands in the Western Ghats mountain range in south-western India (Alström and Mild 2003).

All members of the Motacillidae family feed largely on small invertebrates. The wide, but long, and pointed bill of the pipits is perfectly adapted for picking prey from soft sand, among rocks and pebbles, and in short vegetation. A huge array of invertebrates is eaten by pipits. Insects predominate its diet, but a wide variety of other arthropods ranging from spiders, and other arachnids, to myriapods, worms, small terrestrial, freshwater or marine molluscs, and crustaceans are also consumed. Seeds and other vegetable material are eaten by many species of pipits (Simms 1992), but they form a small part of the diet. For many motacillids, there is still rather little information available on the diet other than the fact that small insects and other invertebrates are eaten (Tyler 2004).

Pipits and wagtails are chiefly insect-eaters, flies especially adult Diptera are preferred. Beetles, grasshoppers and other ground-living insects, may also appear in pipit diets.

While watching birds near Rajmalai shola, Eravikulam National Park, Kerala, on June 01, 2010, I noticed a Nilgiri Pipit feeding in a shallow flow of water over a sprawling granite rock. The clear water trickling down from the shola was barely 1-3 cm deep except for some scattered puddles. The bird was actively catching insects from the surface of the water. At times I observed it catching insects from deep puddles by immersing its whole head into water. I observed the pipit's activity from 09:30 to 10:15 hrs without a break. A large number of the catch was mostly picked from the surface of the water. Obviously, it was capitalizing on abundant supply of prey in the flowing water.

While most wagtails, and those pipits with long claws that favour wetland habitats, are known to wade in shallow water to pick aquatic invertebrates, the Nilgiri Pipit "forages on ground, in short grass" (Tyler 2004).

Regarding its food and feeding habits, Ali and Ripley (1998) mention "insects and small seeds" as its food but do not describe foraging habits. Nevertheless, like most motacillids it appears to be catholic in its choice of insects and also opportunistic.

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3. DISCOVERY OF A LARGE HERONRY AT CHHATA, NEAR MATHURA, IN WESTERN UTTAR PRADESH

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The Delhi region has several heronries (Urfi 1993) of which the most well-known are the ones located inside the premises of the Delhi Zoo (Urfi 1997) and Sultanpur National Park (Urfi *et al.* 2007). In antiquity, other heronries, now

Table 1: Different species of colonial waterbirds observed in Chhata heronry during October 2011

Species	Nests	Nestlings	Adults
Painted Stork *Mycteria leucocephala*	81	6	123
Oriental White Ibis *Threskiornis melanocephalus*	42	-	130
Asian Openbill *Anastomus oscitans*	4	12	-
Little Cormorant *Phalacrocorax niger*	8	-	11
Oriental Darter *Anhinga melanogaster*	2	4	6
Grey Heron *Ardea cinerea*	3	4	2
Intermediate Egret *Egretta intermedia*	-	-	5
Black-crowned Night-Heron *Nycticorax nycticorax*	-	-	3
Indian Pond-Heron *Ardeola grayii*	-	-	4
Little Egret *Egretta garzetta*	-	-	11

extinct, are also recorded such as the one adjoining Mansi Ganga tank in Govardhan (Hume and Oates 1890) and at Faridabad (MacDonald 1962). In this note, we describe another large, hitherto unreported, heronry at a tank in Chhata, close to Mathura.

Chhata town (27° 43' 37" N; 77° 30' 30" E), in Mathura district, lies on National Highway 2, connecting Delhi to Mathura. On several occasions over the past few years, Painted Stork *Mycteria leucocephala* have been observed circling in the sky close to the town. But this year, on October 06, 2011, when we got off the main road and walked a short distance from the town, close to a medieval structure (some sort of fortress perched on an elevated spot) which is visible from the main road, we found a large heronry with several nesting species of birds. During our subsequent visits, besides making some general observations on the heronry and the tank, we also counted the nests, nestlings and adults of various species.

Located on the western bank of River Yamuna, Chhata town has a small pond, locally known as 'Surajkund', which was estimated to be *c*. 0.04 sq. km, using the imagery available on Google Earth (Google Earth Pro 2011). It has two islands, one larger, estimated to be *c*. 759.83 sq. m, with several Mesquite (*Prosopis juliflora*) trees (n > 20), and the other smaller, with ruins of abandoned structures, along with growth of Mesquite and *Phragmites* sp. Nests of different bird species seen in a heronry were spread all over the canopy of trees on the large island. Interestingly, some nests were so low that they were close to the water surface. On enquiring the locals revealed that the heronry had been around for several years, with some claiming that it was about a hundred years old.

Among the several birds (Table 1), the largest species at Chhata was the Painted Stork. A total of 81 nests of this species were recorded, of which five were in the canopy of Mesquite trees, growing on a smaller island. Of the 6 nestlings observed, three were estimated to be 10 days post hatching (DPH) and three were much older (about 45-60 DPH). The nestlings were aged on the basis of their body plumage and general morphology as described in Shah and Desai (1975). This confirms the general observation that egg laying in Painted Stork is asynchronous.

Chhata tank was observed to be heavily infested (*c*. 30% of the total water surface) with Water Hyacinth *Eichhornia crassipes*. In fact, the hyacinth mats were so dense that patches of open water were hardly visible. Though tests on water quality were not conducted, the water seemed polluted as the garbage from nearby settlements was being dumped there. While more studies by our group are being planned on this interesting heronry we recommend that this site should be included in the list of IBAs (Islam and Rahmani 2004), especially in light of the fact that at least three species of threatened birds (Table 1), Painted Stork, Oriental White Ibis and Oriental Darter (BirdLife International 2011), nest here.

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4. BREEDING OF CAPTIVE RETICULATED PYTHON *BROGHAMMERUS RETICULATUS* FROM THE NICOBAR ISLANDS

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Introduction

Broghammerus reticulatus is a species of python found in Southeast Asia. Adults can grow over 8.7 m in length, being the average about 3-6 m, and are the world's longest snakes (Murphy and Henderson 1997). It is distributed over Southeast Asia from the Nicobar Islands, Bangladesh, Myanmar, Thailand, Laos, Cambodia, Vietnam, Malaysia and Singapore, east through the Indo-Australian Archipelago and the Philippines (McDiarmid *et al.* 1999) in evergreen forests, and is semi-aquatic in habit. It largely feeds on small mammals, birds and reptiles. It occasionally feeds on medium-sized mammals like wild pig, monkey, deer (Shine *et al.* 1999). It lays eggs in a large clutch, between 15 and 80 eggs per clutch (Mattison 1999). The mother python exhibits considerable parental care till the eggs are hatched.

Methods

This study was carried out during 2010 at Mini Zoo, Haddo, Port Blair. An adult healthy pair was selected for breeding. The male was 2.4 m long and female was 3.6 m long. Both the animals originate from the Great Nicobar Island.

Great Nicobar Island: The Great Nicobar Island is the southernmost island of Andaman and Nicobar archipelago. It is situated between 6°45'-7°15' N and 93°38'-93°55' E, lies about 482 km south of Port Blair and about 145 km north of Sumatra. The Island includes the Great Nicobar Biosphere Reserve, Campbell Bay and Galathea National Park. This area is known for its unique biodiversity and bears rich genetic germplasm resources. The Great Nicobar Island represents the tropical rainforest in Andaman and Nicobar Islands. The vegetation is mainly tropical evergreen forest of Indo-Malayan biogeographic region. It houses 650 species of angiosperms, ferns and gymnosperms. The tree fern *Cyathea albosetacea* is dominant in many parts of the Island. Other important plant species are *Scaevola sericea*, *Heritiera littoralis*, *Pandanus* spp., *Terminalia bialata*, *Barringtonia pendula*, *Rhizophora* spp., *Gnetum gnemon*, *Sterculia macrophylla*, *Elaeocarpus aristatus* (Sinha 1999). The important faunal elements of the island include the Long-tailed Macaque *Macaca fascicularis*, Nicobar Treeshrew *Tupaia nicobarica*, Nicobar Megapode *Megapodius nicobariensis*, Great Nicobar Serpent-eagle *Spilornis klossi*, Nicobar Pigeon *Caloenas nicobarica*, Nicobar Parakeet *Psittacula caniceps*, Edible-nest Swiftlet *Aerodramus fuciphagus*. It is also the habitat of two tribes of Indo-Mongoloid stock, namely the Nicobarese and Shompen (Tikader and Das 1985).

Breeding enclosure: The breeding pair was kept in a 3 m x 3 m x 3 m concrete room, the front was covered with toughened glass pane and wire mesh. The glass pane was provided to avoid accidental injury to the animal on hitting the wire mesh. The top of the room was thatched with dried leaves to facilitate diffused sunlight into the cage. About 45 per cent of the cage was under partial shade. The cage was provided with dead sturdy branches and a concrete waterhole to facilitate comfortable stay of the animal.

Food: The pair was fed with live animals, e.g., domestic fowl, weighing 1.5 kg, every fortnight.

Results and Discussion

The female was introduced into the male's enclosure in the first week of October 2009; courtship and mating was observed from the third day. Mating continued till January. The highest mating frequency was observed during December and January. Mating was observed on 10 occasions, during morning, evening, and night; copulation ranged from 25 to 30 minutes.

Gestation period, clutch and egg size: The gestation period was considered from the date of last mating to the date of egg laying. The last mating was observed on January 12, 2010, and five eggs were laid on April 02, 2010. The average egg length was 10.6 cm and weight 210 gm (Table 1). All the eggs were incubated by the female in the enclosure; the incubation period was 72 days. The temperature in the enclosure ranged from 31 to 32 °C and humidity from 80 to 90 per cent. The gestation period lasted for 81 days.

During the incubation period, the female completely avoided food and was observed quivering. Cage shade was increased from 45 per cent to 60 per cent in February and March 2010; water was sprayed on the roof to provide relief against rising temperatures.

Table 1: Egg measurements of *Broghammerus reticulatus*

Batch No.	Egg layed	Clutch size	Average length (cm)	Average width (cm)	Average weight (gm)	Incubation period (days)
1	02.iv.2010	5	10.6	6.3	210	72

Out of five eggs, only two hatched; both the hatchlings were marked. Their average total body length (head to tail) was 70 cm and weight 39 gm. The growth of body length of hatchlings varied between individuals. The growth of the two hatchlings was measured: hatchling number 1 and 2, on 20.vi.2010 (80 cm, 60 cm), 10.x.2010 (84 cm, 71 cm), 10.xi.2010 (86 cm, 72 cm), respectively.

During the present study, mating was observed from December to January, which indicates that the temperature influences the reproductive activity of this species. The observed period of mating was similar to *Python molurus* (Ross and Marzec 1990). The gestation period of 81 days was more than *Python molurus* (Dattatri 1990; Ross and Marzec 1990). The variation in weight and size of hatchlings may be due to varying temperatures during the incubation period. According to Vineger (1973), temperature not only affects metabolic activity in ectothermic animals, but also plays a vital role in the development of embryos. The captive management of Reticulated Python emphasizes that if certain basic parameters and individual care are provided to the species breeding can be successful.

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5. NEW RECORD OF TWO SPECIES OF EELS OF THE GENUS *GYMNOTHORAX* (MURAENIDAE) IN DIGHA COAST OF INDIA

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Marine eels of the family Muraenidae are a large group in the Indian waters. There are reports of 35 species under eight genera belonging to Family Muraenidae reported in Indian waters. Out of this, 22 species belong to the Genus *Gymnothorax*. So far, only three species have been recorded in the coastal area of Digha (Chatterjee *et al.* 2000). Several efforts were made to inventory marine and estuarine fishes of Digha (Manna and Goswami 1985; Goswami 1992; Talwar *et al.* 1992). Consistent efforts were also made by the Marine Aquarium & Regional Centre, Zoological Survey of India (ZSI), Digha, to update this data by adding recent occurrences. Being the largest public aquarium of the ZSI, efforts are being taken to maintain the diversity of tank exhibits. During the collection of live fishes for exhibition, the authors encountered two more species belonging to the Genus *Gymnothorax* around Digha coastal waters;*G favagineus* and *G javanicus*. Both the specimens were collected live around Digha coast and displayed in the aquarium.

Classification

Class: Actinopterygii
Order: Anguilliformes
Family: Muraenidae
Genus: *Gymnothorax*

***Gymnothorax favagineus* Bloch & Schneider 1801**

Enchelycore favagineus (Bloch & Schneider 1801). *Systema Ichthyologiae.*: i-lx + 1-584, Pls. 1.

Material examined: 2 ex, TL 65-71 cm, Locality: 1 ex Digha, 12.xii.1996, Coll: T.K. Chatterjee & Party, Reg. No. 30, 1 ex Kirtaniya, 24.vii.2009. Reg No. 579.

Diagnostic characters: Body elongate, snake-like, stout; pale brown to yellow colour with closely set numerous large round black blotches; pattern continuous to the edges of the mouth.

Common Names: *Gymnothorax favagineus* is commonly known as the Black-spotted Moray, Honeycomb Moray, Coral Eel, Giraffe Eel (Australia), Honeycomb Moray (Indonesia, SA, USA).

Distribution: Indo-Pacific: Red Sea and East Africa to Papua New Guinea, north to southern Japan, Taiwan, south to Australia. From Indian waters the species is reported only from Andaman and Nicobar Islands (Rao 2003).

***Gymnothorax javanicus* (Bleeker 1859)**

Muraena javanica Bleeker, 1859. *Natuurkundig Tijdschrift voor Nederlandsch Indië* v. 19: 329-352.

Gymnothorax javanicus (Bleeker, 1859). *Natuurkundig Tijdschrift voor Nederlandsch Indië* v. 19: 329-352.

Material examined: 1 ex, TL *c*. 65 cm, Digha, 18.viii.2007, Coll.: Prasanna Yennawar & P. Tudu, Reg No. 522.

Diagnostic characters: Body elongated, snake-like. Eye nearer to the tip of the snout than to the corner of the mouth; Dorsal fin moderately high, its origin on rear of head about equidistant between rectus muscle and gill opening; black specks that grade into leopard-like spots behind the head and a black area surrounding the gill opening.

Common Names: *Gymnothorax javanicus* (Bleeker 1859) is commonly known as Giant Moray, Tropical Moray Eel (USA), Blackpearl Moray (Australia), Java Moray Eel (Papua New Guinea).

Distribution: Indo-Pacific: Red Sea and East Africa to the Marquesas and Oeno Atoll (Pitcairn Group), north to the Ryukyu and Hawaiian islands, south to New Caledonia and the Austral Islands. From Indian waters the species is reported from Andaman and Nicobar Islands (Devi and Rao 2003; Rao 2003).

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6. NOTE ON AN ADDITIONAL LOCALITY FOR *CROCE FILIPENNIS* WESTWOOD, 1841 (NEUROPTERA: NEMOPTERIDAE)

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Globally, the family Nemopteridae is represented by 41 genera and about 150 species (Oswald 2007a). Of these, only four genera and six species are reported from India (Ghosh 1998). Though *Croce filipennis* seems to be an endemic and widely distributed species in India (Maxwell-Lefroy and Howlett 1971), very little information is available about its confirmed localities.

Genus *Croce* MacLachlan, 1885 is represented by a single species, namely *Croce filipennis* Westwood, 1841 in India (Mansell 1986; Oswald 2007b), and recorded from Bengal, Central India, and the United Provinces (Imms 1911). In Maharashtra, this species was first reported by Sharma *et al.* (2001) from Tadoba-Andhari Tiger Reserve, Chandrapur. Sharma *et al.* (2001) reported two additional distribution records based on specimens collected from Lakhani village, Bhandara, and one mutilated specimen from Pune. Apart from this, Chandra and Thilak (2007) reported its first records from Madhya Pradesh.

In view of lack of information about the distribution of this species any information about its additional locality is noteworthy.

On March 17, 2009, a specimen of spoonwing *Croce filipennis* was deposited in the Collection Department of Bombay Natural History Society (Day book entry No. 01/2009). The insect was found dead in a house at Marol, Sakinaka, Mumbai. It was identified as *Croce filipennis* Westwood 1840, as its general morphology matched the original description (Westwood 1841) and the descriptions provided by subsequent authors (Ghosh 1910; Imms 1911). Its identity was further confirmed by comparing the wing venation with the illustration by Comstock (1918).

The measurements, colour and other details are as follows: The deposited specimen measures 6 mm in length. Length of individual forewing is 9.25 mm and wing span of forewing is 20 mm. The thread-like hind wings measure 23 mm. The insect is blackish grey. The forewing is membranous, narrow at the base and broader in the middle. The specimen has a black stigma on the costal region just behind the apex. The inner margin of the forewing is fringed with small, uniform hairs, except near the base. The hind wing is narrow, hairy, thread-like, tapering at the end and projecting backwards. Hind wings are four times longer than body. Mouth parts are modified forming a rostrum; eyes large, bulging.

The detailed life history of *C. filipennis* is given by Ghosh (1910) and Imms (1911). These insects are highly specialized and important predators. The larvae of this insect are predaceous and with a characteristically long neck (Imms 1911).

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7. HOST PREFERENCE AND REPORT OF TWO NEW HOST PLANTS OF *LORANTHUS LONGIFLORUS* AT INDORE, MADHYA PRADESH, INDIA

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Introduction

Species of the Mistletoe family characteristically show parasitism. *Loranthus* is recorded from Sumatra, New Guinea, Ceylon (now Sri Lanka), Pakistan (Abdulla 1973), India, Thailand, Australia, China, Bangladesh, Malaysia, Myanmar (Pattanayak *et al.* 2008) and United Provinces (India) (Srivastava 1935). *Loranthus longiflorus* is distributed throughout India (Chopra 1975). A large number of host plants of *L. longiflorus* are reported by various scientists (Srivastava 1935; Sampathkumar and Kunchithapatham 1969; Narayanasamy and Sampathkumar 1981; Sampathkumar and Selvaraj 1981; Balsubramanian and Sugathan 1986; Sawant *et al.* 2008).

Study Area and Method

Indore is situated at 22° 48' N and 75°48' E, 553 m above mean sea level. The campus of Government Holkar Science College (an area of about 36 acres) and its adjoining area and Vasudeonagar (an area about 5 acres), Indore, Madhya Pradesh, were selected to survey the host range of *Loranthus longiflorus*. 762 flowering plants of 60 species were screened between January 15 and April 15, 2009. This is a common species in the urban area of Indore.

Results and Discussion

Loranthus longiflorus Desr. flourished on 7 out of 43 species in the study area. Two host plants: *Albizia lebbeck*

Table 1: Host range relationship of *Loranthus longiflorus* in the campus and adjoining area of Government Holkar Science College, Indore, M.P.

S. No.	Plant Studied	Family	Total no. of studied	Total no. of infected
1.	*Aegle marmelos*	Rutaceae	2	0
2.	*Acacia nilotica*	Mimosaceae	57	0
3.	*Albizia lebbeck*	Mimosaceae	16	10
4.	*Annona squamosa*	Annonaceae	4	0
5.	*Azadirachta indica*	Meliaceae	60	5
6.	*Artocarpus heterophyllus*	Moraceae	1	0
7.	*Butea monosperma*	Papilionaceae	1	0
8.	*Ceiba pentandra*	Bombacaceae	9	0
9.	*Caesalpinia pulcherrima*	Caesalpiniaceae	8	0
10.	*Cordia myxa*	Boraginaceae	16	2
11.	*Cassia fistula*	Caesalpiniaceae	11	0
12.	*Delonix regia*	Caesalpiniaceae	13	0
13.	*Emblica officinalis*	Euphorbiaceae	9	0
14.	*Eucalyptus camaldulensis*	Myrtaceae	46	1
15.	*Syzygium cumini*	Myrtaceae	41	0
16.	*Ficus benghalensis*	Moraceae	3	0
17.	*Ficus racemosa*	Moraceae	7	0
18.	*Ficus religiosa*	Moraceae	18	1
19.	*Leucaena leucocephala*	Mimosaceae	29	0
20.	*Mangifera indica*	Anacardiaceae	40	15
21.	*Mimusops elengi*	Sapotaceae	6	0
22.	*Peltophorum acerifolium*	Caesalpiniaceae	46	0
23.	*Pithecellobium dulce*	Mimosaceae	47	1
24.	*Pterospermum acerifolium*	Sterculiaceae	1	0
25.	*Phoenix sylvestris*	Palmae	13	0
26.	*Mitragyna parviflora*	Rubiaceae	4	0
27.	*Santalum album*	Santalaceae	68	0
28.	*Polyalthia longifolia*	Annonaceae	20	0
29.	*Tamarindus indica*	Caesalpiniaceae	23	0
30.	*Ziziphus mauritiana*	Rhamnaceae	10	0
31.	*Kigelia pinnata*	Bignoniaceae	1	0
32.	*Dalbergia sissoo*	Papilionaceae	2	0
33.	*Madhuca longifolia*	Sapotaceae	2	0
34.	*Pongamia pinnata*	Papilionaceae	12	0
35.	*Tectona grandis*	Verbenaceae	1	0
36.	*Bombax malabaricum*	Bombacaceae	7	0
37.	*Bauhinia variegata*	Caesalpiniaceae	1	0
38.	*Grevillea robusta*	Proteaceae	9	0
39.	*Millingtonia hortensis*	Bignoniaceae	3	0
40.	*Acacia leucophloea*	Mimosaceae	1	0
41.	*Morinda tinctoria*	Rubiaceae	3	0
42.	*Cassia siamea*	Caesalpiniaceae	7	0
43.	*Ixora parviflora*	Rubiaceae	3	0

(62.5%) and *Mangifera indica* (37.5%) seem to be most susceptible (Table 1). However, in Vasudeonagar colony 10 out of 29 species were affected. Here, *Mangifera indica* (58.33%) and *Grevillea robusta* (44.44%) were the preferred hosts of *Loranthus*. Two new hosts, i.e., *Pseuderanthemum atropurpureum* (Acanthaceae) and *Lagerstroemia indica* (Lythraceae) (Table 2), were observed during this study. Occurrence of *Loranthus* on these shrubs, grown as ornamentals, proves that it has tremendous adaptability for hosts. *L. longiflorus* generally prefers big trees with well-developed lenticels on bark, but in this case the condition did not appear to be applicable. Infection of *Loranthus* on these shrubs appeared to be by chance. Another important feature recorded during the study was that *L. longiflorus* does not grow on monocots, probably as monocots have scattered vascular bundles and penetration of *Loranthus* roots in the xylem of the host may be difficult.

Pseuderanthemum atropurpureum is nearly 3.65 m tall having several (38 to 40) thick and thin branches arising from the stem at ground level. *Loranthus* had attacked a 0.9 cm diameter branch. Interestingly, the apical portion of this branch was dead after infection. This plant was *c.* 12.19 m away from three infected plants. Another host *Lagerstroemia indica*, was *c.* 3.05 m tall, *c.* 6.09 m from two infected plants. More than 300 species of host plants of *Loranthus longiflorus* have been reported in literature (Srivastava 1935; Suryaprakash *et al.* 1967; Sampathkumar and Kunchithapatham 1969; Narayanasamy and Sampathkumar 1981; Sampathkumar and Selvaraj 1981; Indrani and Balasubramanian 1985; Balsubramanian and Sugathan 1986; Ramchandranair and Krishanakumar 1989; Pattanayak *et al.* 2008; Sawant *et al.* 2008), but none have reported these two hosts. Therefore, these two species are new reports for India. In our view, this parasite is not host specific; infection success depends on favourable conditions at the time the seed falls on the host. Narayanasamy and Sampathkumar (1981) report higher osmotic pressure of semi-parasite than hosts for infection success.

Loranthus longiflorus is one of the most important traditional medicinal species. Its medicinal properties are greatly influenced by the host plant (Jain 1997; Pattanayak *et al.* 2008), therefore, further study is required for evaluation of *Loranthus longiflorus* on the new reports.

Table 2: Host range relationship of *Loranthus longiflorus* in Vasudeonagar, Indore, M.P.

S. No.	Plant Studied	Family	Total no. of studied	Total no. of infected plants
1.	*Cassia fistula*	Caesalpiniaceae	3	1
2.	*Lagerstroemia indica*	Lythraceae	2	1
3.	*Plumeria alba*	Apocynaceae	3	0
4.	*Peltophorum acerifolium*	Caesalpiniaceae	3	0
5.	*Pongamia pinnata*	Papilionaceae	2	0
6.	*Azadirachta indica*	Meliaceae	3	1
7.	*Delonix regia*	Caesalpiniaceae	1	0
8.	*Millingtonia hortensis*	Bignoniaceae	3	0
9.	*Grevillea robusta*	Proteaceae	9	4
10.	*Moringa oleifera*	Moringaceae	2	0
11.	*Psidium guajava*	Myrtaceae	7	2
12.	*Mangifera indica*	Anacardiaceae	12	7
13.	*Ficus religiosa*	Moraceae	1	0
14.	*Annona reticulata*	Annonaceae	1	1
15.	*Michelia champaca*	Magnoliaceae	1	0
16.	*Bambusa* sp.	Bombacaceae	1	0
17.	*Cocos nucifera*	Palmae	2	0
18.	*Gardenia jasminoides*	Rubiaceae	1	0
19.	*Cassia renigera*	Caesalpiniaceae	1	0
20.	*Cordia myxa*	Boraginaceae	1	0
21.	*Hibiscus rosa-sinensis*	Malvaceae	2	0
22.	*Ficus racemosa*	Moraceae	1	1
23.	*Terminalia catappa*	Combretaceae	2	0
24.	*Bauhinia variegata*	Caesalpiniaceae	1	0
25.	*Callistemon lanceolatus*	Myrtaceae	1	1
26.	*Alstonia scholaris*	Apocynaceae	11	0
27.	*Melia azadirachta*	Meliaceae	2	0
28.	*Pseuderanthemum atropurpureum*	Acanthaceae	1	1
29.	*Thevetia neriifolia*	Apocynaceae	1	0

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8. *SELAGINELLA RETICULATA* (HOOK. & GREV.) SPRING (SELAGINELLACEAE) – A NEW RECORD TO THE PTERIDOPHYTIC FLORA OF RAJASTHAN, NORTH-WESTERN INDIA

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Rajasthan in north-west India is the largest state with an area of 3,42,274 sq. km and lies between 23° 3'-30° 12' N and 69° 30'-78° 17' E. Aravalli ranges, which are one of the oldest mountain ranges of the world, diagonally divide the state into two distinct climatic regions. The region towards the north-western side of Aravalli is a desert or semi-desert characterized by sand dunes, high wind velocity, high temperature and thorny vegetation. The region towards the south-eastern side is a humid zone with hills of variable heights, ravines, plains, rivers and dense forests.

Sitamata Wildlife Sanctuary (Fig. 1) is one of the protected areas of Rajasthan with a wide range of habitats in the Aravalli ranges. It is exceptional for diversity and interspersed habitats, which includes areas of teak stands, perennial streams, sloping hills and fine groves of mixed woodlands. The Sanctuary lies on the Udaipur-Pratapgarh state highway at a distance of 100 km from Udaipur and 40 km from Pratapgarh. The major part of the Sanctuary lies in the newly formed civil district of Pratapgarh, only 74.21 sq. km comes under district Chittorgarh. The Sanctuary covers an area of 422.95 sq. km (195.09 sq. km core area and 227.86 sq. km buffer area) and lies between 24° 04'-24° 23' N and 74° 25'-74° 40' E. The occurrence of flying squirrel is the greatest attraction of the Sanctuary.

Geographically, there are three major operating systems, namely the Aravalli, the Vindhyan and Malva plateau, which result in a variety of habitats. The annual rainfall in the Sanctuary area ranges from 664.60 mm to 1,430.20 mm with an average 30 rainy days. The temperature varies from 18.6-33.6 °C.

Selaginella Beauv. with 700 species (Pichi-Sermolli 1977) is represented by 62 species in India (Alston 1945; Panigrahi and Dixit 1966, 1967, 1968; Dixit 1984, 1992). The first enumeration of the Indian species of *Selaginella* was provided by Alston (1945). Subsequently, Panigrahi and Dixit (1966, 1967, 1968) carried out prolonged research on this genus and dealt with 30 species of *Selaginella* in detail. Sharma and Bhardwaja (1976) have reported the occurrence of *Selaginella repanda* (Desv.) Spring for the first time from Gwaparnath, Kota (south-east Rajasthan). A new species of *Selaginella*, namely *Selaginella rajasthanensis* was described by Gena *et al.* (1979) from Kunda Khoh, Shahabad, Baran district of Rajasthan. Recently, Dulawat and Chaudhary (2008) have recorded *Selaginella ciliaris* (Retz.) Spring from Sitamata, Rajasthan. The present paper deals with the detailed taxonomic account, distribution and ecological notes of *Selaginella reticulata* recorded from Sitamata forest in Rajasthan.

An extensive survey of the area of Sitamata Wildlife Sanctuary was carried out during 2004-2009. Various localities which seem likely to support the growth of *Selaginella* were visited regularly, especially during rainy season (July-October). Field observations, such as habit, habitat, associated plants were recorded. Identification was done using Alston (1945), Panigrahi and Dixit (1966), and Dixit (1984, 1992). Morphological observations and camera

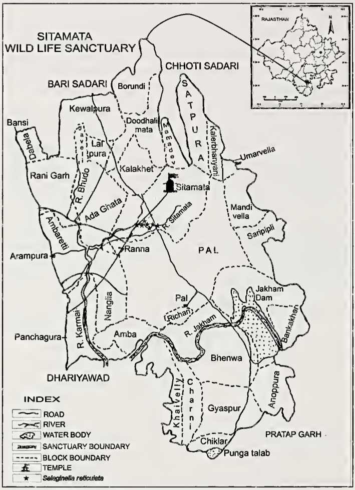
SITAMATA
WILD LIFE SANCTUARY
CHHOTI SADARI
BARI SADARI
Borundi
Kewalpura
Bansi
Dabela
Doodhali mata
SATPURA
Lar pura
Kalakhet
Kalerbhanyani
Umarvella
Rani Garh
R. Bhudo
Sitamata
Ada Ghata
R. Sitamata
Mandi vella
Saripipli
Ambaretti
Arampura
Ranna
PAL
Jakham Dam
Pal
Richan
R. Jakham
Nangiia
R. Karmai
Panchagura
Amba
Bankakhen
Bhenwa
Anoppura
DHARIYAWAD
Charni
Khaivelly
Gyaspur
Chiklar
PRATAP GARH
Punga talab
RAJASTHAN
N
INDEX
ROAD
RIVER
WATER BODY
SANCTUARY BOUNDARY
BLOCK BOUNDARY
TEMPLE
Selaginella reticulata

Fig. 1: Map of Sitamata Wildlife Sanctuary, Rajasthan, India

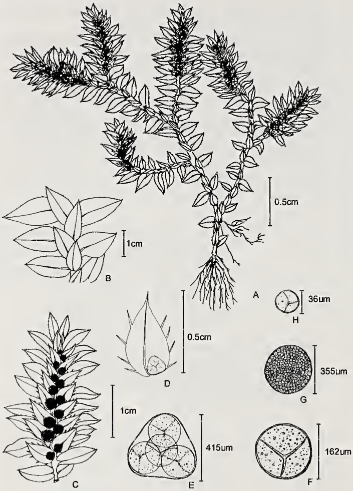
0.5cm
1cm
B
A
36um
H
0.5cm
D
355um
G
1cm
C
415um
E
162um
F

Fig. 2: A-H *Selaginella reticulata*, A. Habit, B. Lateral and Median leaves, C. Strobilus, D. Megasporophyll, E. Megasporangium, F. Megaspore, G. Microsporangium, H. Microspore

lucida drawings were made under a microscope. Voucher specimens were deposited in the Herbarium, Department of Botany, M.L.V. Government College, Bhilwara.

During search for pteridophytes in Sitamata Wildlife Sanctuary, the authors collected some plant specimens of *Selaginella* from a river valley on way to Sitamata temple (Fig. 1) of the Sanctuary. After a thorough survey of literature, critical examination and expert opinion, the specimens were determined as *Selaginella reticulata* (Fig. 2) of Selaginellaceae, a taxon not recorded by earlier workers from Rajasthan.

Taxonomic Account

Selaginella species of lycopod, *Selaginella reticulata* (Hook. & Grev.) Spring in Bull. Ac. Brux. X, p.233 (sep.p.33), no. 155 (1843). *Lycopodium reticulatum* Hook. & Grev. *In* Hook. Bot. Misc. II p. 402, no. 185 (1831). *L. tetragonstachyum* Wall. Cat. No. 124 (1829) p.p. nomen.

Plant erect, 1.0–1.5 cm high, rooting at base only, Stem cylindrical, glabrous, branched from the base, branches alternate; rhizophore wiry, restricted to basal one third. Leaves dimorphic throughout, membranous, bright green; lateral leaves oblong or elliptic, acute, 1.2 x 0.59 mm, denticulate; median leaves ovate, cordate, acute, 0.72 x 0.39 mm denticulate. Spike 3.0-5.0 mm, Sporophylls dimorphic; smaller sporophylls fertile with long cilia, ovate, acuminate; larger sporophylls sterile oblong-elliptic, acute, dentate. Megasporangia 10-12, 380-543 µm; megaspores trilete circular 153-180 µm in diameter with reticulations on exine. Microsporangia 1-3 restricted to the basal part of the strobilus, 344-380 µm; microspores trilete, circular brick red in colour, 36-40 µm, exine sparsely studded with tubercles.

Fertile: September-October.

Earlier records: Eastern Himalaya, Myanmar.

Specimens Examined: River valley on way to Sitamata Wildlife Sanctuary, Rajasthan, Yadav & Meena 06.ix.2009, MLVGCB Herb., 3007.

Field notes: Rare, plant growing amidst moss and *Selaginella repanda* on the moist slope of a river valley. The small size made it difficult to spot among moss in nature.

S. rajasthanensis has been reported by Gena *et al.* (1979) as a new species of *Selaginella* from Rajasthan, India. However, Fraser-Jenkins (2008) has treated this species as the synonym of *S. reticulata*. *Selaginella reticulata* resembles

S. rajasthanensis Gena, Bhardwaja & Yadav in general appearance, but is very different from the latter in habitat (erect *vs* prostrate), branching (repeated *vs* uncommon), rhizophores (basal *vs* throughout), lateral leaf (acute *vs* obtuse), sporophylls (ciliated *vs* serrate).

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9. REDISCOVERY OF ENDEMIC *USNEA* SPECIES FROM WESTERN GHATS, INDIA

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Introduction

India is known to have eight lichenogeographical regions (Singh and Sinha 1997) (Fig. 1). The diverse climatic and habitat conditions of these regions provide favourable conditions for speciation that leads to endemism.

India has 2,303 lichen species in 305 genera with about 22.5% endemism (Singh and Sinha 2010) and particularly in regions like the Western Ghats endemism is high compared to the other parts of the country. The region enjoys tropical climate and is one of the richest lichen sites of India. 800 species have been reported from this region, of which 219 species, i.e. 27.27% of total lichen flora at regional level and 10.68% at national level, are endemic (Singh *et al.* 2004).

The statistic of endemism, as well as distributional records, of many species is subject to change as some of these are known only from a single collection, and type locality, (Singh *et al.* 2004). Endemic species are most vulnerable to extinction, as they occupy a narrow geographical area or region.

During our several collection efforts in different regions of the Western Ghats, we came across some interesting findings on the lichen genus *Usnea* Dill. ex. Adans. It is

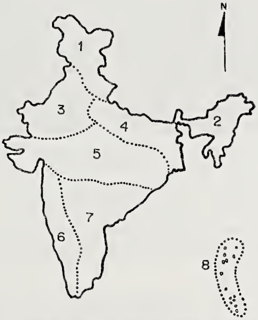

Fig. 1: Map showing Lichenogeographic regions of India (Singh & Sinha 1997)

1. Western Himalaya Region; 2. Eastern Himalaya Region; 3. Western Dry Region; 4. Gangetic plains; 5. Central India; 6. Western Ghats; 7. Eastern Ghats & Deccan plateau; 8. Andaman & Nicobar Islands

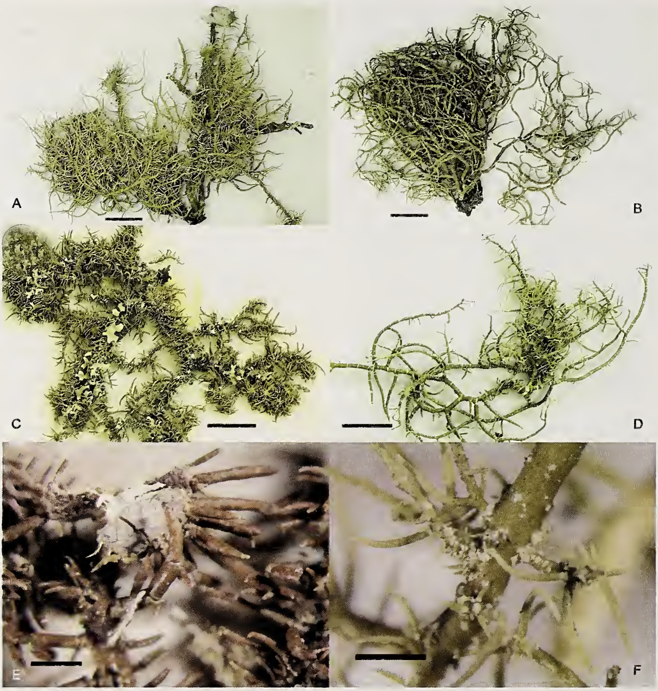

Fig. 2: *Usnea* spp., Habit a–f: a. *Usnea austroindica*, b. *Usnea nilgirica*, c. *Usnea strigosa*, d. *Usnea tumida* (Bar = 10mm), e. *Usnea strigosa* showing apothecia and prominent fibrils, f. *Usnea tumida* showing sorediate isidia (Bar = 1mm)

represented by 338 species globally and in India by 60 species and a variety, of which 18 species are endemic to India. About 12 species of *Usnea* are known only from the Tamil Nadu–Western Ghats of India (Awasthi 1986; Singh and Sinha 2010).

After the monographic work on *Usnea* by Motyka (1936-38), studies on this genus from India were carried out by Awasthi (1986). According to recent trends the generic status and the circumscription of *Usnea* is limited to subgenus *Eumitra* and *Euusnea* (= *Usnea*). Of the known 60 species from India, three species: *Usnea austroindica*, *U. nilgirica* and *U. tumida* were hitherto known only from their type localities. These species have been recently collected by us from Tamil Nadu.

Though *Usnea tumida* and *U. strigosa* are included in the key to species, their description and illustration are not given by Awasthi (2007). Further, these species have been listed as excluded taxa in the annotated checklist of Indian lichens (Singh and Sinha 2010).

Several records from Tamil Nadu need to be validated by undertaking fresh meticulous surveys; we strongly feel that this effort would certainly clarify the current biodiversity status of many endemic lichen elements. And this will in turn enhance the lichen diversity of India.

A detailed description along with chemical data, and illustrations of *Usnea strigosa* and *U. tumida* (Fig. 2), and diagnostic characters of *U. austroindica* and *U. nilgirica* have been provided for easy identification.

Usnea austroindica G. Awasthi

J. Hattori Bot. Lab. 61: 364. (1986). (Fig. 2a)

Type: India, Tamil Nadu, Shembaganur, alt. 6000 ft, on tree of *Acrocarpus*, 15.xii.1959, *Foreau* (Holotype: No. 4180A in Hb. Awas.).

Thallus fruticose, corticolous, erect, spiny branchlets not sorediate, dichotomously branched, sympodial, branches spine-like, articulated. Main axis more or less central, verrucose or with depressions, outer cortex orangish-pinkish brown, medulla not hollow, with loose hyphae to thickish, central core which is solid, hyaline to orangish-pink. Pseudocyphellae, soredia and isidia absent. Apothecia concolorous with the thallus, large wide open verrucose on the lower side, stalked, with spines all over 3-8 mm wide, concave, white disc, slightly, powdery, margin ciliate, cilia 1-2 mm long; Usnic and barbatic acids present.

The first report of *Usnea austroindica* was in 1959 from Tamil Nadu followed by 1970; it has been collected again in 2010, after about 30 years.

Specimens Examined: India, Tamil Nadu, Kodaikanal, Gundar forest, 9.x.2010, U.V. Makhija & S.B. Gaikwad, 10.480; Kodaikanal, Bryant Park, 9.x.2010, U.V. Makhija & P.S. Khadilkar, 10.102.

Usnea nilgirica G. Awasthi

J. Hattori Bot. Lab. 61: 351, 1986. (Fig.2b)

Type: India, Nilgiri hills (Herb. Ind Or.) *Hook. Fils & Thomson* 1720 (Holotype: BM).

Thallus erect to pendulous, dichotomous, sympodial branching, ends tapering, pointed, articulated, isidiate, with white patches all over and also minute spiny outgrowths seen from it, soredia absent; papillate, main axis more or less circular, cracked in outline, with spines on the outer side, cortex with hyaline to brownish chondroid tissue, medulla partially hollow, interwoven, central axis solid, I-. Apothecia not seen; Usnic, protocetraric and barbatic acids present.

This species has been collected recently, after 14 years, in 2010 during our extensive field survey in Tamil Nadu. The species was, so far, known only from its type locality – Nilgiri hills.

Specimens Examined: India, Tamil Nadu, Ooty-Pykara, 11.x.2010, U.V. Makhija & M. Morey, 10.607, 10.611, 10.612, 10.614; U.V. Makhija & P.S. Khadilkar, 10.582, 10.583.

Usnea strigosa (Ach.) Eaton

In: *Man. Bot. ed.* 5., 1829 p 431 (Fig. 2c,e,f)

= *U. florida* var. *strigosa* Ach. *In*: *Method. Lich.*, 1803, p. 310 tb. VI-fig.3 (haud exacta!).

Type: In: H locality-Jamaica *secundum schedam; Secundum opera Acharii America septentrionalis*, Swartz.

Thallus corticolous, fruticose, erect, 4-7 cm long, with excurrent branching, olivaceous green to brownish; base short, rigid not attenuated; branches terete (appear angular due to thick cover of fibrils), 0.7-1.3 (-1.5) mm thick, gradually attenuated towards the apices, esorediate, tuberculately verrucose (may be due to emerging stiff fibrils). Thallus covered by stiff, rigid short, spinuliform fibrils. Apices terminated by apothecia. Cortex reddish-brown, 90-(100) 144 µm thick; medulla white, compact, red at periphery, 234-450 µm thick, central axis hyaline, solid, 450-486 µm in diam. Without isidia and soredia. Apothecia 2-8 mm in diam., terminal; disc concave to plane, brownish to pale yellow, white pruinose; exciple smooth but wrinkled in juvenile and spinulate in adult apothecia; marginal cilia exactly similar to fibrils; ascospores simple, hyaline, ellipsoid, 8.4-10.6 x 6.3-8.4 µm; Usnic acid, norstictic acid (minor) and salazinic acids present.

Usnea strigosa (Ach.) Eaton has been excluded (Awasthi 1986) and the same has been followed till date (Awasthi 2007; Singh and Sinha 2010). It is commonly known as the busy beard lichen and four different chemical strains have been reported (Hale 1962). The species was earlier reported by Hue and Jatta from Himalayas (Hue 1899; Jatta 1911). Later Moreau reported it from Kodaikanal as *Usnea florida* var. *strigosa* (Moreau and Fernaud 1952). The species has been widely distributed in North America (Brodo *et al.* 2001).

Specimens Examined: India, Tamil Nadu, Sims Park, Coonoor, Nilgiris, 16.ix.1973, P.G. Patwardhan & M.B. Nagarkar, 73.787.

Additional Specimens Examined: Louisiana State University Herbarium, Lichens of Texas, Hardin Co.: Pine Island Bayou floodplain just south of farm road 770 bridge, about 6 miles west of Saratoga. Palmetto-hardwood forest, 26.xi.1976, Coll: Cynthia Trxell 601; Ex Duke University Herbarium, North Carolina, On dead branches of *Prunus*, 4 miles south-east of Rolesville, Wake Co., Oct 1955. W.L. Culberson No. 4746.

Usnea tumida Mot.

Lich. Gen. Usnea Monogr., fasc. 3, 611 (1938). (Fig. 2d)

Type: Japonia, *loco exactius non indicato, Locus classicus*: *Wichura. In*: Museo Botanico Berlin.

Thallus fruticose, corticolous, 5-7.5 cm tall, pale to slightly dark green, sorediate-isidiate, dichotomously branched up to the apices, sympodial, isotomic, 1-2.5 cm in diam., unevenly branched, branchlets sorediate, tapering at the apex; main axis slightly circular to angular in cross section, uneven, rough, articulated; outer cortex hyaline, not pigmented, prosoplectenchymatous, non-transparent, 30-37.5 µm thick; algal layer green, 12.5-25 µm thick; medulla solid in structure but also loosely arranged 200-212.5 µm thick; central axis solid hyaline, 150 µm thick. Apothecia not seen; Stictic, constictic, connorstictic, usnic acid, sometimes consoromic, norstictic, protocetraric and salazinic acids seen. Collected from the Nilgiri forests at an altitude of 2,300 m.

In the monographic work of Motyka (1936-38) *U. tumida* is reported from the Nilgiri hills of India, but its chemical data is not available. However, Awasthi (2007) included it only in the key. The species is now reported by us from this region, after a lapse of 73 years from Gundar forest of Kodaikanal (*c.* 2,133 m). This species is distributed only in Tamil Nadu and outside India in Japan, Madagascar and Sumatra.

Specimens Examined: India, Tamil Nadu, Kodaikanal, Bryant Park, 8.x.2010, U.V. Makhija & P.S. Khadilkar, 10.103; Kodaikanal, Gundar forest, 9.x.2010, U.V. Makhija & S.B. Gaikwad, 10.473, 10.475, 10.476, 10.478, 10.479, 10.479, 10.483, 10.485, 10.486.

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Preface

Conservation and appreciation of wildlife is deep-rooted in Indian culture and ethos; the Vedas, Indian epics, and records by the Mughals vouch for this. Interest in birds in particular has been unequivocal in the country from time immemorial. Almost all Indian languages and dialects have common names for each bird species or even subspecies, reflecting the understanding of birds in indigenous knowledge systems, perhaps arising from their utility in traditional healing systems, at times even entering the realm of superstition. Legends are manifold regarding the divinity of certain birds and the protection granted to them by legendary heroes and rulers. However, systematic documentation of birds in the Subcontinent began only during the colonial period.

India is endowed with more than 1,200 species of birds; over 170 of these species are endemic to the Subcontinent. A publication by the Bombay Natural History Society identifies 466 Important Bird Areas in the country with respect to species richness, endemicity, and global share of population of certain key species. Birds have fascinated humankind, even inspiring us to incorporate several avian features in modern technology. It was the study of living birds that paved the way to revealing several basic principles of ecology and ecological/species dynamics. While we derive immense tangible and intangible ecological services from these species, not much is recognised or valued by the so-called market forces. Pitted against the race for human development, many species are losing their struggle for survival.

Globally, scientific studies on birds began during the 17th century. In India, research in ornithology was pioneered by stalwarts such as S.R. Tickell, T.C. Jerdon, Edward Blyth, Brian Hodgson, A.O. Hume, Hugh Whistler, T.C. Ticehurst, Sálim Ali, and S.D. Ripley. In due course, many more studies were taken up, and many more youngsters have taken to avian research and birdwatching, and thereby to conservation of biodiversity and nature, with Dr. Sálim Ali's work playing an inspirational role. In view of the mounting pressure of market forces on natural habitats, it was felt that it is time to take stock of the developments in the field of avian studies, identify the gaps, and deliberate upon the strategy to proceed further, both in research and conservation.

In this context, the idea of organising the biennial International Conference on Indian Ornithology (ICIO) was mooted by the former Minister for Environment and Forests, Government of India, and President of Sálim Ali Centre for Ornithology and Natural History (SACON), Coimbatore, Mr. Jairam Ramesh. The conference was meant to extend a platform for researchers, managers, and policy makers to come together, present their findings and views, and to deliberate upon the progress of research in the field.

The first Conference, ICIO-2011, with the theme *Status of Indian Birds and their Conservation* was held at the Sálim Ali Centre for Ornithology and Natural History, Coimbatore, during November 19 to 23, 2011, in association with the Bombay Natural History Society, Mumbai. During the Conference, in ten symposia, 153 research papers covering 25 Indian states and all biogeographic zones of the country were presented. Besides the plenary and special lectures, special poster and speed talk sessions were held, especially to encourage young researchers.

In all, 300 participants from 10 countries attended the conference. Dr. Pamela C. Rasmussen, Michigan State University; Dr. Rhys Green, Royal Society for the Protection of Birds and Department of Zoology, University of Cambridge; Dr. Mohammad Ali Reza Khan, Dubai Zoo, UAE; Mr. Christopher Bowden, RSPB, UK; Dr. Trevor Price, University of Chicago; Mr. Ian Barber, RSPB, UK; and veteran conservationists such as Mr. Lavkumar Khacher were notable among the participants. Senior officials from the Ministry of Environment and Forests, Government of India, forest and wildlife managers of several State Forest Departments, academicians, conservationists, researchers, non-government organisations, and nature lovers attended the conference. Officials from the MoEF, GoI, included Dr. Dilip Kumar, then Director General of Forests & Special Secretary, MoEF, and Mr. Hem Pande, then Joint Secretary to Government of India, MoEF; Prof. Paul P. Appasamy, then Vice Chancellor, Karunya University and eminent environmental economist; Dr. E.J. James, Member, Wetland Authority of India; Dr. E.K. Bharucha, Director, Bharati Vidyapeeth Deemed University, Pune; Dr. K. Vijayakumaran, Director General, Fisheries Survey of India; Dr. Vinod Kumar, Delhi University; and Dr. K.S. Krishnan, National Centre for Biological Sciences, Bengaluru, were among the eminent participants.

The extended abstracts of the papers were published and released at the time of the conference. Now, a compilation of select papers, representing a cross section of the works presented in the conference, is being published in this special issue of the *Journal of the Bombay Natural History Society*.

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THEN AND NOW: NEW DEVELOPMENTS IN INDIAN SYSTEMATIC ORNITHOLOGY

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In this paper, I contrast the state of Indian systematic ornithology prior to 2005 with new developments. My frame of reference is research for the second edition of BIRDS OF SOUTH ASIA: THE RIPLEY GUIDE (Rasmussen and Anderton 2012), in comparison with the state of knowledge at the time of the first (2005) edition. In contrast to the past, there has been a recent explosion of systematic and taxonomic studies of Indian birds, though there are still many problems and uncertainties to be resolved. Although it was not possible to reorganise avian groups on a large scale in the second edition, we have enacted many well-corroborated changes in nomenclature, familial relationships, and generic realignments, among others. For widespread taxa, many of these have already been adopted by official committees, such as the British Ornithological Union Records Committee (BOURC, http://www.bou.org.uk/british-list/) and American Ornithologists' Union North American Classification Committee (NACC, http://www.aou.org/checklist/north/print.php). Since 2005, ornithological resources are now much more widely available and democratized, with the development of huge online photographic and audio databases (http://macaulaylibrary.org/, http://ibc.lynxeds.com/, http://orientalbirdimages.org/, http://www.xeno-canto.org/, http://avocet.zoology.msu.edu/) that now provide data for most South Asian species. There are now many open access journals, freely available older publications, and expansion and improvement of online encyclopedic resources and global systematic lists (e.g., http://www.birdlife.org/datazone/info/taxonomy, http://worldbirdnames.org/, http://www.birds.cornell.edu/clementschecklist/, http://jboyd.net/Taxo/taxo1.html). For those with institutional connections, most publications can now be viewed from one's own computer. And there is now a large contingent of knowledgeable, experienced, committed South Asian field ornithologists, birders, and photographers, which has led to a massive increase in documented, reliable field data and many major recent publications and resources (e.g. Harvey *et al.* 2006; Manakadan *et al.* 2011; Sashikumar *et al.* 2011; Pittie 2012).

By 2005, a revolution had started in the systematics of Asian birds. It had become clear that *Erpornis*, *Pteruthius*, and *Pseudopodoces* were seriously misclassified, that *Sylvia* warblers were closer to some babblers than to other warblers, and that such lineages as *Alcippe* and *Garrulax* were in need of major revision (Cibois *et al.* 2002; James *et al.* 2003). Since then, DNA sequencing has largely resolved the evolutionary history of many of the most troublesome lineages, such as the great muscicapine assemblage (Alström *et al.* 2011a, b; Klicka *et al.* 2005; Moyle *et al.* 2012; Nguembock *et al.* 2007; Sangster *et al.* 2010; Voelker and Spellman 2004; Zuccon and Ericson 2010a). Mainly on the basis of some of these studies, the former Sylviidae (as constituted in Rasmussen and Anderton 2005) is now broken up into the cettiids Cettiidae, grasshopper and bush-warblers Locustellidae, reed-warblers Acrocephalidae, phylloscopids Phylloscopidae, and sylviid warblers Sylviidae. Other major changes include the finding that the tit-warblers *Leptopoecile* are related to long-tailed tits *Aegithalos* (Päckert *et al.* 2010), but the long-tailed tits are part of the warbler radiation. The parrotbills are not babblers (Gelang *et al.* 2009; Moyle *et al.* 2012; Pasquet *et al.* 2006; Yeung *et al.* 2011), and the Bearded Reedling *Panurus biarmicus* is neither a parrotbill nor a babbler, but a monotypic family (Alström *et al.* 2006; Ericson and Johansson 2003). The shrike-babblers *Pteruthius* and *Erpornis* are best placed within New World vireos Vireonidae (Reddy and Cracraft 2007). Other surprises are that *Pnoepyga* wren-babblers are not related to other babblers (Gelang *et al.* 2009), and that *Scotocerca* is not a prinia but a cettiid (Alström *et al.* 2011c). The golden-plovers are not closely related to the other plovers (Baker *et al.* 2007a; Ericson *et al.* 2003; Fain and Houde 2007). The storm-petrels fall into two divergent lineages best considered separate families (Hackett *et al.* 2008). The noddies are not closely related to other terns (Baker *et al.* 2007a; Bridge *et al.* 2005). The sandgrouse are now placed in their own order, Pteroclidiformes (Ericson *et al.* 2006; Hackett *et al.* 2008), the tropicbirds in their own order Phaethontiformes (Fain and Houde 2004; Hackett *et al.* 2008), and the flamingos likewise in their own order Phoenicopteriformes, related to grebes Podicipediformes (Brown *et al.* 2008; Mayr 2008; Sangster 2005). The Ibisbill is placed in a separate family Ibidorhynchidae (Baker *et al.* 2007a). The Yellow-bellied Fantail *Chelidorhynx hypoxanthus* [formerly placed in Rhipiduridae and even (by others) in *Rhipidura*, but differing obviously in behaviour and vocalisations], along with the Grey-headed Canary-flycatcher *Culicicapa ceylonensis*, are related to a small assemblage of otherwise African birds, the Stenostiridae (Beresford *et al.* 2005; Fuchs *et al.* 2009). The woodshrikes *Tephrodornis* and flycatcher-shrikes *Hemipus* are not related to cuckooshrikes, but to the African and Malagasy Vangidae (Reddy *et al.* 2012). The Mountain Tailorbird *Phyllergates cuculatus*, long thought a tailorbird *Orthotomus* despite its aberrant biology, has been found to belong with the cettiid warblers (Alström *et al.* 2006, 2011b). The yuhinas are related to white-eyes, and are now in the Zosteropidae (Moyle *et al.* 2009; Zhang *et al.* 2007).

Since 2005, an entirely new, highly distinctive species of Indian bird, the Bugun Liocichla *Liocichla bugunorum*, has been discovered (Athreya 2006); the heretofore almost unknown Mishmi Wren-babbler *Spelaeornis badeigularis* (King and Donahue 2006) is now routinely recorded, and the single known specimen of Large-billed Reed-warbler *Acrocephalus orinus*, until recently known only from a single 1867 specimen is now much better known (Round *et al.* 2007; Svensson *et al.* 2008, 2010); Sillem's Mountain-finch has been rediscovered (Kazmierczak and Muzika 2012) in China; and an evidently new species of *Rallina* crake has been photographed in the Nicobar Islands (Rajeshkumar *et al.* 2012). Other new information may be less spectacular, but still noteworthy. For example, the Forest Eagle-owl *Ketupa* [*Bubo*] *nipalensis*, formerly thought restricted to the Himalayas, Western Ghats, and Sri Lanka, has been found to occur in Central India (Jayapal *et al.* 2005), and the Lesser Fish-eagle *Ichthyaetus humilis*, never before proven to occur far from the Himalayas within South Asia, is now known to occur in several sites in South India (e.g., Praveen and Nameer 2009). No fewer than three species of large, distinctively marked *Turdus* thrushes (Kessler's Thrush *Turdus kessleri*, Chestnut Thrush *T. rubrocanus gouldi*, Tibetan Blackbird *T. maximus*) for which definitive evidence was nearly or entirely lacking for the north-east of India have now been photographically documented for these regions (photographs on OBI). And, the Western Cattle Egret *Bubulcus ibis* has been found to occur in Pakistan (UMMZ specimens).

Several species considered hypothetical in BIRDS OF SOUTH ASIA owing to inadequate documentation have now been conclusively shown to occur, such as Eastern Marsh-harrier *Circus spilonotus* and Black-browed Reed-warbler *Acrocephalus bistrigiceps* (http://orientalbirdimages.org/), and there are credible recent reports (if not absolute proof) of other species previously considered hypothetical such as Green Peafowl *Pavo muticus* (M.M. Khan, pers. comm. 2011), Oriental Stork *Ciconia boyciana* (M.M. Khan, pers. comm. 2011), and Sooty Falcon *Falco concolor* (Khan *et al.* 2010). Two new species are added to the hypothetical list: Australian Shelduck *Tadorna tadornoides* and Lanner Falcon *Falco biarmicus*, both on the basis of birds of probable captive origin in the Chagos (Carr 2011). The species list of any region will continue to grow with further study and the passage of time, and new species recorded for South Asia since 2005 (Table 1) include Crested Tit-warbler *Leptopoecile elegans* (Sangha *et al.* 2007), Chestnut-cheeked Starling *Agropsar philippensis* (van der Wielen 2007), Blue-and-white Flycatcher *Cyanoptila cyanomelana* (photographed near Alibag, Maharashtra by P. Kawale, March 10, 2012), Long-tailed Jaeger *Stercorarius longicaudus* (sighted in Maldives, Anderson 2007; images from Sri Lanka on OBI) and Band-rumped Storm-petrel *Oceanodroma castro* (Anderson 2007; if split, the form recorded is unknown). There has also been one documented regional extinction (Table 1), the Siberian Crane *Leucogeranus* [*Grus*] *leucogeranus*, which still occurs in China.

The most common category of taxonomic repercussions resulting from the many systematic studies involving South Asian birds published since 2005 has been generic realignments (Table 1). Discussing generic changes in detail are beyond the scope of this paper, but the view was taken here that genera should be broad enough to reflect relationships to a certain extent but not so broad as to force inclusion of highly distinctive taxa, and that when equally informative and accurate, existing generic arrangements should be retained. I am not philosophically opposed to monotypic genera, where treatment as monotypic is informative as to the level of distinctiveness, and as long as monophyly is maintained. Also, where putative generic realignments were based only on a single gene or short sequences, especially if they seemed counterintuitive and/or would have resulted in wholesale name changes that may later have to be reversed, it was deemed best to await further genetic or other evidence before enacting them. In many cases there are multiple possible alternative generic arrangements that are technically correct, so different authorities may arrive at different conclusions.

Numerous taxonomic splits proposed in the first edition of BIRDS OF SOUTH ASIA have been validated by further studies published in peer-reviewed journals. These include (those occurring or at least hypothetical in South Asia in bold): ***Anas poecilorhyncha*/*A. zonorhyncha*** (Leader 2006); ***Gyps indicus*/*G. tenuirostris*** (Arshad *et al.* 2009; Johnson *et al.* 2006); ***Buteo buteo*/*B. burmanicus*** (Kruckenhauser *et al.* 2004; Penhallurick and Dickinson 2008); ***Rallus aquaticus*/ *R. indicus*** (Sangster *et al.* 2011; Tavares *et al.* 2010); ***Charadrius alexandrinus*** /*C. nivosus* (Chesser *et al.* 2011; Küpper *et al.* 2009); ***Gallinago gallinago***/*G. delicata* (Knox *et al.* 2008); ***Caprimulgus macrurus*/*C. andamanicus*** (Sangster and Rozendaal 2004); *Chrysocolaptes lucidus*/ ***C. guttacristatus*/*C. stricklandi*** (Collar 2011); several babblers (e.g., Collar 2006; Collar and Robson 2007); ***Turdus merula*/ *T. maximus*/*T.*** *mandarinus*/***T. simillimus*** (Nylander *et al.*

2008); ***Myiomela major/M. albiventris*** (Robin *et al.* 2010); *Cettia acanthizoides*/***C. brunnescens*** (Alström *et al.* 2007); and ***Turdus ruficollis/T. atrogularis*** (Knox *et al.* 2008); among others. Most of the others have been accepted by IOC and the Clements checklist projects. Grimmett *et al.* (2011) summarise those officially accepted by the Oriental Bird Club.

Several cases mentioned as possible splits in Rasmussen and Anderton (2005) but not treated as such therein are now split on the basis of new and/or more thoroughly studied evidence: ***Egretta intermedia*** (split from *E. brachyrhyncha* of Africa and *E. plumifera* of Australia, mainly on the basis of the very different soft part colours in breeding plumage, as well as proportions and calls); ***Gallinula chloropus***/*G. galeata* (Groenenberg *et al.* 2008; Chesser *et al.* 2011); ***Numenius phaeopus***/*N. hudsonicus* (Johnsen *et al.* 2010; Kerr *et al.* 2009; Sangster *et al.* 2011); ***Otus modestus*** (split from ***Otus sunia***, on the basis of consistently and markedly distinct songs); ***Chrysocolaptes socialis*** (split from ***Chrysocolaptes guttacristatus*** on the basis of strongly divergent drumrolls and calls); ***Pomatorhinus phayrei*** (split from ***P. ferruginosus*** on the basis of strongly differing morphology, vocalisations, and DNA divergence; Reddy and Moyle 2011); ***Locustella thoracica/L. kashmirensis*** (Alström *et al.* 2008a); *Certhia familiaris*/***C. hodgsoni*** (Tietze *et al.* 2006); ***Sitta castanea***/*S. neglecta* (IOC 2.11); ***Pachyglossa agilis*** (split from *P. obsoleta* on the basis of very different morphology and calls).

In addition, many splits between regional species and extralimital ones not proposed in Rasmussen and Anderton (2005) have been published, nearly all subsequent to the first edition's proof stage (Table 1), including (those occurring in South Asia in bold): ***Gavia arctica***/*G. pacifica* (many sources, e.g. Knox *et al.* 2008); *Puffinus lherminieri*/***P. bailloni*** (Austin *et al.* 2004); ***Egretta alba***/*E. egretta* (Pratt 2011); ***Sarkidiornis melanotos***/*S. sylvicola* (IOC 2.11); ***Melanitta fusca***/*M. deglandi* (Chesser *et al.* 2010; Collinson *et al.* 2006; Sangster *et al.* 2005); ***Pandion haliaetus***/*P. cristatus* (Christidis and Boles 2008; Wink *et al.* 2004); *Chlamydotis undulatus*/***C. macqueenii*** (IOC 2.11); ***Rostratula benghalensis***/*R. australis* (Baker *et al.* 2007b); ***Thalasseus sandvicensis***/*T. acuflavidus* (Efe *et al.* 2009; Sangster *et al.* 2011); ***Tyto alba***/*T. delicatula* (IOC 2.11); ***Troglodytes troglodytes***/*T. hiemalis*/*T. pacificus* (Drovetski *et al.* 2004; Toews and Irwin 2008; Chesser *et al.* 2010); *Turdus naumanni*/***T. eunomus*** (Knox *et al.* 2008); ***Copsychus saularis***/*C. mindanensis* (Sheldon *et al.* 2009); *Saxicola torquatus*/***S. maurus*** (Zink *et al.* 2009; note that the proposed split of *stejnegeri* is not adopted due to lack of inclusion of *przewalskii* in the study); *Oenanthe lugens*/***O. persica*** (Förschler *et al.* 2010); ***Graminicola bengalensis***/*G. striatus* (Leader *et al.* 2010); ***Garrulax leucolophus***/*G. bicolor* (Collar 2006; Collar and Robson 2007); ***Garrulax albogularis***/*G. ruficeps* (Collar 2006; Collar and Robson 2007); ***Dryonastes galbanus***/*D. courtoisi* (Collar and Robson 2007); ***Liocichla phoenicea***/*L. ripponi* (Collar and Robson 2007); *Pteruthius flaviscapis*/***P. aeralatus*** (Rheindt and Eaton 2009); *Pteruthius aenobarbus*/***P. intermedius*** (Rheindt and Eaton 2009); *Pomatorhinus erythrocnemis*/***P. mcclellandi*** (Collar and Robson 2007); ***Aegithalos iouschistos***/*A. bonvaloti* (IOC 2.11; but note low genetic divergence, Päckert *et al.* 2010); ***Salpornis spilonotus***/*S. salvadori* (Tietze and Martens 2010); ***Arachnothera longirostris***/*A. flammifera*/*A. dilutior* (Lohman *et al.* 2010; Moyle *et al.* 2011; Rahman *et al.* 2010).

Splits proposed between at least two regional species include: ***Nisaetus nipalensis/N. kelaarti*** (Gjershaug *et al.* 2008); ***Falco peregrinus/F. peregrinoides*** (many sources); ***Cuculus saturatus/C. optatus***/*C. lepidus* (King 2005); ***Apus pacificus/A. leuconyx/A. salimali*** (Leader 2011); ***Monticola solitarius/M. philippensis*** (Zuccon and Ericson 2010b); ***Phylloscopus reguloides/P. claudiae*** (Olsson *et al.* 2005); ***Paradoxornis ruficeps/P. bakeri*** (King and Robson 2008); ***Aegithalos concinnus/A. iredalei*** (Päckert *et al.* 2010); ***Parus major/P. cinereus/P. minor*** (Eck and Martens 2006; Päckert *et al.* 2005); ***Certhia discolor/C. manipurensis*** (Tietze *et al.* 2006).

Conversely, some long-accepted species, after further study, are now treated as subspecies: e.g., *Larus heuglini* = *L. fuscus* (Collinson *et al.* 2008), *Lanius meridionalis* = *L. excubitor* (Klassert *et al.* 2008, Olsson *et al.* 2010), *Parus melanolophus* = *P. ater* (Eck and Martens 2006), *P. flavipectus* = *P. cyanus* (Eck and Martens 2006), *P. bokharensis* = *P. major* (Eck and Martens 2006), in each case of more widely distributed species (Table 1). In the case of *Lanius excubitor*, further research will almost certainly result in splitting of this highly morphologically and genetically polytypic species complex, but results thus far do not allow confident conclusions.

A few species previously thought to be Indian endemics or at least South Asian breeding endemics are now known to occur outside the region's limits, for example Large-billed Reed-warbler (Timmins *et al.* 2009), Tickell's Thrush *Turdus unicolor* (Yu 2007), and Large Blue Flycatcher *Cyornis magnirostris* (Renner *et al.* 2009).

The existence of comprehensive photo and sound databases and/or archives has made it possible to utilise the vast amounts of data being stored in further assessing species limits. For example, examination of the Plain Flowerpecker *Dicaeum concolor* revealed that, despite their drab coloration, within Indian limits there are three markedly different groups, treated in Rasmussen and Anderton (2005) as Nilgiri Flowerpecker *D. concolor*; Andaman Flowerpecker *D. virescens*; and Plain Flowerpecker *D. minullum*. At the time no good photographs existed of the first two, and now

Table 1: Status, taxonomic and scientific name changes in Rasmussen & Anderton (2012) second, revised edition, as compared to the first edition (2005). Does not include minor emendations in spelling. References cited either directly provided the taxonomic recommendations adopted, or provided data and/or a taxonomic framework that led to the conclusions adopted in Rasmussen & Anderton (2012)

Name in 2nd edition	Status change	References/authority followed
Black-throated Diver *Gavia arctica*	split from extralimital taxa	Knox *et al.* 2008
Flesh-footed Shearwater *Ardenna carneipes*	generic change from *Puffinus*	Austin *et al.* 2004; Olson & Rasmussen 2001
Sooty Shearwater *Ardenna grisea*	generic change from *Puffinus*	Austin *et al.* 2004; Olson & Rasmussen 2001
Wedge-tailed Shearwater *Ardenna pacifica*	generic change from *Puffinus*	Austin *et al.* 2004; Olson & Rasmussen 2001
Short-tailed Shearwater *Ardenna tenuirostris*	generic change from *Puffinus*	Austin *et al.* 2004; Olson & Rasmussen 2001
Tropical Shearwater *Puffinus bailloni*	split from extralimital taxa	Austin *et al.* 2004
Band-rumped Storm-petrel *Oceanodroma castro*	addition; if split, species uncertain	Anderson 2007; Smith *et al.* 2007
Pygmy Cormorant *Microcarbo pygmeus*	generic change from *Phalacrocorax*	Christidis & Boles 2008; Kennedy *et al.* 2000
Little Cormorant *Microcarbo niger*	generic change from *Phalacrocorax*	Christidis & Boles 2008; Kennedy *et al.* 2000
Intermediate Egret *Egretta intermedia*	split from extralimital taxa	Rasmussen & Anderton 2012
Great Egret *Egretta alba*	split from extralimital taxa	Pratt 2011
Oriental Stork *Ciconia boyciana*	to regular list from hypothetical	M.M. Khan, pers. comm.
Australian Shelduck *Tadorna tadornoides*	new for hypothetical list	Carr *et al.* 2011
Knob-billed Duck *Sarkidiornis melanotos*	split from extralimital taxa	IOC 2.11
Baikal Teal *Sibrionetta formosa*	generic change from *Anas*	Bulgarella *et al.* 2010; Gonzalez *et al.* 2009
Falcated Duck *Mareca falcata*	generic change from *Anas*	Bulgarella *et al.* 2010; Gonzalez *et al.* 2009; Peters *et al.* 2005
Eurasian Wigeon *Mareca penelope*	generic change from *Anas*	Bulgarella *et al.* 2010; Gonzalez *et al.* 2009; Peters *et al.* 2005
Gadwall *Mareca strepera*	generic change from *Anas*	Bulgarella *et al.* 2010; Gonzalez *et al.* 2009; Peters *et al.* 2005
Northern Shoveler *Spatula clypeata*	generic change from *Anas*	Bulgarella *et al.* 2010; Gonzalez *et al.* 2009
Garganey *Querquedula querquedula*	generic change from *Anas*	Bulgarella *et al.* 2010; Gonzalez *et al.* 2009
Velvet Scoter *Melanitta fusca*	split from extralimital taxa	Collinson *et al.* 2006; Sangster *et al.* 2005
Western Osprey *Pandion haliaetus*	split from extralimital taxa	IOC 2.11
Rufous-bellied Eagle *Lophotriorchis kienerii*	generic change from *Hieraaetus*	Haring *et al.* 2007
Bonelli's Eagle *Aquila fasciata*	generic change from *Hieraaetus*	Helbig *et al.* 2005; Lerner & Mindell 2005
Legge's Hawk-eagle *Nisaetus kelaarti*	split from regional taxon; generic change from *Spizaetus*	Gjershaug *et al.* 2008; Haring *et al.* 2007
Mountain Hawk-eagle *Nisaetus nipalensis*	generic change from *Spizaetus*	Haring *et al.* 2007
Crested Hawk-eagle *Nisaetus cirrhatus*	generic change from *Spizaetus*	Haring *et al.* 2007
Changeable Hawk-eagle *Nisaetus limnaetus*	generic change from *Spizaetus*	Haring *et al.* 2007
Indian Spotted Eagle *Clanga hastata*	generic change from *Aquila*	E.C. Dickinson, pers. comm. 2012
Greater Spotted Eagle *Clanga clanga*	generic change from *Aquila*	E.C. Dickinson, pers. comm. 2012
Lesser Spotted Eagle *Clanga pomarina*	generic change from *Aquila*	E.C. Dickinson, pers. comm. 2012
Grey-headed Fish-eagle *Icthyophaga ichthyaetus*	generic change from *Ichthyophaga*	David *et al.* 2009
Lesser Fish-eagle *Icthyophaga humilis*	generic change from *Ichthyophaga*	David *et al.* 2009
Hen Harrier *Circus cyaneus*	split from extralimital	IOC 2.11
Eastern Marsh Harrier *Circus spilonotus*	to regular list from hypothetical	http://orientalbirdimages.org/
Barbary Falcon *Falco pelegrinoides babylonicus*	split from regional taxa	many sources
Lanner Falcon *Falco biarmicus*	new for hypothetical list	Carr *et al.* 2011
Sooty Falcon *Falco concolor*	to regular list from hypothetical	Khan *et al.* 2010
Green Peafowl *Pavo muticus*	to regular list from hypothetical	M.M. Khan, pers. comm. 2011
Siberian Crane *Leucogeranus leucogeranus*	extinct in region; generic change from *Grus*	Krajewski *et al.* 2010
Macqueen's Bustard *Chlamydotis macqueenii*	split from extralimital taxa	several sources
Blue-breasted Quail *Excalfactoria chinensis*	generic change from *Coturnix*	Seabrook-Davison *et al.* 2009
Great Nicobar Crake *Rallina* sp.	undescribed putative new species	Rajeshkumar *et al.* 2012
Slaty-breasted Rail *Gallirallus striatus*	generic change from *Rallus*	IOC 2.11
Common Moorhen *Gallinula chloropus*	split from extralimital taxa	Groenenberg *et al.* 2008; Chesser *et al.* 2011
Greater Painted-snipe *Rostratula benghalensis*	split from extralimital taxon	Baker *et al.* 2007b
Eurasian Dotterel *Charadrius morinellus*	generic change from *Eudromias*	IOC 2.11
Eurasian Whimbrel *Numenius phaeopus*	split from extralimital taxa	Johnsen *et al.* 2010; Kerr *et al.* 2009; Sangster *et al.* 2011

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Name in 2nd edition	**Status change**	**References/authority followed**
Grey-tailed Tattler *Tringa brevipes*	generic change from *Heteroscelus*	Pereira & Baker 2005; Banks *et al.* 2006
Curlew Sandpiper *Erolia ferruginea*	generic change from *Calidris*	Borowik & McLennan 1999; Gibson 2010
Temminck's Stint *Ereunetes temminckii*	generic change from *Calidris*	Borowik & McLennan 1999; Gibson 2010
Sanderling *Ereunetes albus*	generic change from *Calidris*	Borowik & McLennan 1999; Gibson 2010
Dunlin *Ereunetes alpinus*	generic change from *Calidris*	Borowik & McLennan 1999; Gibson 2010
Pectoral Sandpiper *Ereunetes melanotos*	generic change from *Calidris*	Borowik & McLennan 1999; Gibson 2010
Little Stint *Ereunetes minutus*	generic change from *Calidris*	Borowik & McLennan 1999; Gibson 2010
Long-toed Stint *Ereunetes subminutus*	generic change from *Calidris*	Borowik & McLennan 1999; Gibson 2010
Rufous-necked Stint *Ereunetes ruficollis*	generic change from *Calidris*	Borowik & McLennan 1999; Gibson 2010
White-rumped Sandpiper *Ereunetes fuscicollis*	generic change from *Calidris*	Borowik & McLennan 1999; Gibson 2010
Sharp-tailed Sandpiper *Limicola acuminata*	generic change from *Calidris*	Borowik & McLennan 1999; Gibson 2010
Brown Skua *Stercorarius antarcticus*	generic change from *Catharacta*	AOU 2000; Braun & Brumfield 1998
South Polar Skua *Stercorarius maccormicki*	generic change from *Catharacta*	AOU 2000; Braun & Brumfield 1998
Long-tailed Jaeger *Stercorarius longicaudus*	addition	Anderson 2007; OBI
Lesser Black-backed Gull *Larus fuscus heuglini/taimyrensis/barabensis*	lump with extralimital taxa	Collinson *et al.* 2008
Great Black-headed Gull *Ichthyaetus ichthyaetus*	generic change from *Larus*	Banks *et al.* 2008; Pons *et al.* 2005
Slender-billed Gull *Chroicocephalus genei*	generic change from *Larus*	Banks *et al.* 2008; Pons *et al.* 2005
Brown-headed Gull *Chroicocephalus brunnicephalus*	generic change from *Larus*	Banks *et al.* 2008; Pons *et al.* 2005
Common Black-headed Gull *Chroicocephalus ridibundus*	generic change from *Larus*	Banks *et al.* 2008; Pons *et al.* 2005
Relict Gull *Ichthyaetus relictus*	generic change from *Larus*	Banks *et al.* 2008; Pons *et al.* 2005
Little Gull *Hydrocoloeus minutus*	generic change from *Larus*	Banks *et al.* 2008; Pons *et al.* 2005
Sooty Gull *Ichthyaetus hemprichii*	generic change from *Larus*	Banks *et al.* 2008; Pons *et al.* 2005
White-eyed Gull *Ichthyaetus leucophthalmus*	generic change from *Larus*	Banks *et al.* 2008; Pons *et al.* 2005
Little Tern *Sternula albifrons*	generic change from *Sterna*	Banks *et al.* 2007; Bridge *et al.* 2005
Saunders's Tern *Sternula saundersi*	generic change from *Sterna*	Banks *et al.* 2007; Bridge *et al.* 2005
Sandwich Tern *Thalasseus sandvicensis*	split from extralimital taxa	Efe *et al.* 2009
Bridled Tern *Onychoprion anaethetus*	generic change from *Sterna*	Banks *et al.* 2007; Bridge *et al.* 2005
Sooty Tern *Onychoprion fuscatus*	generic change from *Sterna*	Banks *et al.* 2007; Bridge *et al.* 2005
Laughing Dove *Spilopelia senegalensis*	generic change from *Streptopelia*	IOC 2.11
Spotted Dove *Spilopelia chinensis*	generic change from *Streptopelia*	IOC 2.11
Madagascar Turtle-dove *Nesoenas picturatus*	generic change from *Streptopelia*	IOC 2.11
Himalayan Cuckoo *Cuculus saturatus*	split from largely extralimital taxa	King 2005
Horsfield's Cuckoo *Cuculus optatus*	split from region and extralimital taxa	King 2005
Common Barn-owl *Tyto alba* (excluding *delicatula*)	split from extralimital taxa	IOC 2.11
Snowy Owl *Bubo scandiacus*	generic change from *Nyctea*	Wink *et al.* 2009
Forest Eagle-owl *Ketupa nipalensis*	generic change from *Bubo*	Wink *et al.* 2009
Walden's Scops-owl *Otus modestus*	split from regional taxa	Rasmussen & Anderton 2012
Great Eared-nightjar *Lyncornis macrotis*	generic change from *Eurostopodus*	Han *et al.* 2010
Blyth's Swift *Apus leuconyx*	split from largely extralimital taxa	Leader 2011
Sálim Ali's Swift *Apus salimali*	split from regional taxon	Leader 2011
Narcondam Hornbill *Rhyticeros narcondami*	generic change from *Aceros*	Viseshakul *et al.* 2011
Plain-pouched Hornbill *Rhyticeros subruficollis*	generic change from *Aceros*	Viseshakul *et al.* 2011
Wreathed Hornbill *Rhyticeros undulatus*	generic change from *Aceros*	Viseshakul *et al.* 2011
White-throated Brown Hornbill *Anorrhinus austeni*	generic change from *Ptilolaemus*	Viseshakul *et al.* 2011
Coppersmith Barbet *Xantholaema haemacephalus*	generic change from *Megalaima*	Moyle 2004
Ceylon Small Barbet *Xantholaema rubricapillus*	generic change from *Megalaima*	Moyle 2004
Malabar Barbet *Xantholaema malabarica*	generic change from *Megalaima*	Moyle 2004
Speckled Piculet *Vivia innominata*	generic change from *Picumnus*	Fuchs *et al.* 2006
Greater Yellownape *Chrysophlegma flavinucha*	generic change from *Picus*	Fuchs *et al.* 2008
Greater Flameback *Chrysocolaptes guttacristatus*	split from extralimital taxa	Collar 2011

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Name in 2nd edition	Status change	References/authority followed
Malabar Flameback *Chrysocolaptes socialis*	split from regional taxa	Rasmussen & Anderton 2012
Blue Pitta *Hydrornis cyaneus*	generic change from *Pitta*	Irestedt *et al.* 2006
Blue-naped Pitta *Hydrornis nipalensis*	generic change from *Pitta*	Irestedt *et al.* 2006
Streak-throated Swallow *Petrochelidon fluvicola*	generic change from *Hirundo*	Sheldon *et al.* 2005
Red-rumped Swallow *Cecropis daurica*	generic change from *Hirundo*	Sheldon *et al.* 2005
Striated Swallow *Cecropis striolata*	generic change from *Hirundo*	Sheldon *et al.* 2005
Ceylon Swallow *Cecropis hyperythra*	generic change from *Hirundo*	Sheldon *et al.* 2005
Black-winged Cuckooshrike *Lalage melaschistos*	generic change from *Coracina*	Jønsson *et al.* 2010
Black-headed Cuckooshrike *Lalage melanoptera*	generic change from *Coracina*	Jønsson *et al.* 2010
Black-headed Bulbul *Microtarsus atriceps*	generic change from *Pycnonotus*	Moyle & Marks 2006
Andaman Bulbul *Microtarsus fuscoflavescens*	generic change from *Pycnonotus*	Moyle & Marks 2006
Grey-headed Bulbul *Microtarsus priocephalus*	generic change from *Pycnonotus*	Moyle & Marks 2006
Yellow-eared Bulbul *Kelaartia penicillata*	generic change from *Pycnonotus*	Rasmussen & Anderton 2012
Crested Finchbill *Pycnonotus canifrons*	generic change from *Spizixos*	Moyle & Marks 2006
Nicobar Bulbul *Ixos nicobariensis*	generic change from *Hypsipetes*	Moyle & Marks 2006
Mountain Bulbul *Ixos mcclellandii*	generic change from *Hypsipetes*	Moyle & Marks 2006
Yellow-browed Bulbul *Acritillas indica*	generic change from *Iole*	Dickinson & Gregory 2002; IOC 2.11
Great Grey Shrike *Lanius excubitor lahtora/pallidirostris*	lump with extralimital Old World taxa	Klassert *et al.* 2008; Olsson *et al.* 2010
Eurasian Wren *Troglodytes troglodytes*	split from extralimital taxa	Chesser *et al.* 2010; Drovetski *et al.* 2004; Toews & Irwin 2008
Orange-headed Thrush *Geokichla citrina*	generic change from *Zoothera*	Voelker & Klicka 2008
Black-throated Thrush *Turdus atrogularis*	split from regional taxon	Knox *et al.* 2008
Dusky Thrush *Turdus eunomus*	split from extralimital taxon	Knox *et al.* 2008
Black-throated Thrush *Turdus atrogularis*	split from regional taxon	
Spot-winged Thrush *Geokichla spiloptera*	generic change from *Zoothera*	Voelker & Klicka 2008
Pied Thrush *Geokichla wardii*	generic change from *Zoothera*	Voelker & Klicka 2008
Siberian Thrush *Geokichla sibirica*	generic change from *Zoothera*	Voelker & Klicka 2008
Asian Rock-thrush *Monticola philippensis*	split from regional taxon	Zuccon & Ericson 2010b
Oriental Magpie-robin *Copsychus saularis* (except *mindanensis*)	split from extralimital taxa	Sheldon *et al.* 2009
Indian Black Robin *Copsychus fulicatus*	generic change from *Saxicoloides*	Sangster *et al.* 2010
Siberian Blue Robin *Larvivora cyane*	generic change from *Luscinia*	Sangster *et al.* 2010
Indian Blue Robin *Larvivora brunnea*	generic change from *Luscinia*	Sangster *et al.* 2010
Firethroat *Calliope pectardens*	generic change from *Luscinia*	Sangster *et al.* 2010
Himalayan Rubythroat *Calliope pectoralis*	generic change from *Luscinia*	Sangster *et al.* 2010
Siberian Rubythroat *Calliope calliope*	generic change from *Luscinia*	Sangster *et al.* 2010
Siberian Stonechat *Saxicola maurus*	split from extralimital taxa	Illera *et al.* 2008; Zink *et al.* 2009
Jerdon's Bushchat *Rhodophila jerdoni*	generic change from *Saxicola*	Illera *et al.* 2008
Grey Bushchat *Rhodophila ferrea*	generic change from *Saxicola*	Illera *et al.* 2008
Brown Rock-chat *Oenanthe fusca*	generic change from *Cercomela*	Outlaw *et al.* 2010; Sangster *et al.* 2010
Blackstart *Oenanthe melanura*	generic change from *Cercomela*	Outlaw *et al.* 2010; Sangster *et al.* 2010
Plumbeous Water-redstart *Phoenicurus fuliginosus*	generic change from *Rhyacornis*	Sangster *et al.* 2010
White-capped River-chat *Phoenicurus leucocephalus*	generic change from *Chaimarrornis*	Sangster *et al.* 2010
Iranian Wheatear *Oenanthe persica*	split from extralimital taxa	Förschler *et al.* 2010
Mangrove Whistler *Pachycephala cinerea*	specific epithet change	Walters 2003
Nicobar Jungle-flycatcher *Cyornis nicobaricus*	generic change from *Rhinomyias*	Sangster *et al.* 2010
White-gorgeted Flycatcher *Anthipes monileger*	generic change from *Ficedula*	Sangster *et al.* 2010
Pygmy Blue Flycatcher *Ficedula hodgsoni*	generic change from *Muscicapella*	Outlaw & Voelker 2006
Blue-and-white Flycatcher *Cyanoptila cyanomelana*	addition	Kawale photo, 2012
Slaty-backed Flycatcher *Ficedula sordida*	specific epithet change	Outlaw & Voelker 2006
Black-chinned Laughingthrush *Strophocincla cachinnans*	generic change from *Trochalopteron*	Collar & Robson 2007

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Name in 2nd edition	Status change	References/authority followed
Kerala Laughingthrush *Strophocincla fairbanki*	generic change from *Trochalopteron*	Collar & Robson 2007
White-throated Laughingthrush *Garrulax albogularis*	split from extralimital taxon	Collar & Robson 2007; Moyle *et al.* 2012
Grey-sided Laughingthrush *Garrulax caerulatus*	generic change from *Dryonastes*	Luo *et al.* 2009; Moyle *et al.* 2012
White-crested Laughingthrush *Leucodioptron leucolophum*	split from extralimital taxon, generic change from *Garrulax*	Collar & Robson 2007; Luo *et al.* 2009; Moyle *et al.* 2012
Lesser Necklaced Laughingthrush *Leucodioptron monilegerum*	generic change from *Garrulax*	Moyle *et al.* 2012
Spot-breasted Laughingthrush *Leucodioptron merulinum*	generic change from *Stactocichla*	Moyle *et al.* 2012
Yellow-throated Laughingthrush *Dryonastes galbanus*	split from extralimital taxon	Collar & Robson 2007; Moyle *et al.* 2012
Bugun Liocichla *Liocichla bugunorum*	new species	Athreya 2006
Red-faced Liocichla *Liocichla phoenicea*	split from extralimital taxa	Collar & Robson 2007
Pin-striped Tit-babbler *Mixornis gularis*	split from extralimital taxa; generic change from *Macronous*	Collar & Robson 2007; Moyle *et al.* 2012
Rufous-capped Babbler *Cyanoderma ruficeps*	generic change from *Stachyris*	Moyle *et al.* 2012
Rufous-fronted Babbler *Cyanoderma rufifrons*	generic change from *Stachyris*	Moyle *et al.* 2012
Golden Babbler *Cyanoderma chrysaeum*	generic change from *Stachyris*	Moyle *et al.* 2012
Black-chinned Babbler *Cyanoderma pyrrhops*	generic change from *Stachyris*	Moyle *et al.* 2012
Ceylon Scimitar-babbler *Pomatorhinus melanurus*	split from regional taxa	Collar & Robson 2007; Reddy & Moyle 2011
Indian Scimitar-babbler *Pomatorhinus horsfieldii*	split from regional taxa	Collar & Robson 2007; Reddy & Moyle 2011
Streak-breasted Scimitar-babbler *Pomatorhinus ruficollis* (excluding Taiwan *P. musicus*)	split from extralimital taxon	Collar & Robson 2007; Reddy & Moyle 2011
Large Scimitar-babbler *Megapomatorhinus hypoleucos*	generic change from *Pomatorhinus*	Dong *et al.* 2010a; Moyle *et al.* 2012
Spot-breasted Scimitar-babbler *Megapomatorhinus mcclellandi*	split from extralimital taxa, generic change from *Pomatorhinus*	Collar & Robson 2007; Reddy & Moyle 2011
Rusty-cheeked Scimitar-babbler *Megapomatorhinus erythrogenys*	generic change from *Pomatorhinus*	Dong *et al.* 2010a; Moyle *et al.* 2012; Reddy & Moyle 2011
Black-crowned Scimitar-babbler *Pomatorhinus ferruginosus*	split from regional taxa	Reddy & Moyle 2011, Rasmussen & Anderton 2012
Phayre's Scimitar-babbler *Pomatorhinus phayrei*	split from regional taxa	Dong *et al.* 2010a; Moyle *et al.* 2012; Reddy & Moyle 2011
Rufous-winged Fulvetta *Pseudominla castaneceps*	generic change from *Alcippe*	Pasquet *et al.* 2006
Yellow-throated Fulvetta *Pseudominla cinerea*	generic change from *Alcippe*	Pasquet *et al.* 2006
Golden-breasted Fulvetta *Lioparus chrysotis*	generic change from *Alcippe*	Pasquet *et al.* 2006
White-browed Fulvetta *Fulvetta vinipectus*	generic change from *Alcippe*	Pasquet *et al.* 2006
Chinese Fulvetta *Fulvetta striaticollis*	generic change from *Alcippe*	Pasquet *et al.* 2006
Brown-throated Fulvetta *Fulvetta ludlowi*	generic change from *Alcippe*	Pasquet *et al.* 2006
Manipur Fulvetta *Fulvetta manipurensis*	generic change from *Alcippe*	Pasquet *et al.* 2006
Rusty-capped Fulvetta *Schoeniparus dubius*	generic change from *Alcippe*	Pasquet *et al.* 2006
Rufous-throated Fulvetta *Schoeniparus rufogularis*	generic change from *Alcippe*	Pasquet *et al.* 2006
Rufous-backed Sibia *Leioptila annectens*	generic change from *Heterophasia*	Moyle *et al.* 2012
Rufous Sibia *Malacias capistratus*	generic change from *Heterophasia*	Moyle *et al.* 2012
Grey Sibia *Malacias gracilis*	generic change from *Heterophasia*	Moyle *et al.* 2012
Beautiful Sibia *Malacias pulchellus*	generic change from *Heterophasia*	Moyle *et al.* 2012
Blue-winged Minla *Siva cyanouroptera*	generic change from *Minla*	Dong *et al.* 2010b; Moyle *et al.* 2012
Bar-throated Minla *Chrysominla strigula*	generic change from *Minla*	Dong *et al.* 2010b; Moyle *et al.* 2012
Hoary-throated Barwing *Ixops nipalensis*	generic change from *Actinodura*	Dong *et al.* 2010b; Moyle *et al.* 2012
Streak-throated Barwing *Ixops waldeni*	generic change from *Actinodura*	Dong *et al.* 2010b; Moyle *et al.* 2012

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Name in 2nd edition	Status change	References/authority followed
Himalayan Cutia *Cutia nipalensis*	split from extralimital taxon	Collar & Robson 2007; Moyle *et al.* 2012
Spotted Wren-babbler *Elachura formosa*	generic change from *Spelaeornis*	Collar & Robson 2007
Long-billed Wren-babbler *Rimator malacoptilus*	split from extralimital taxa	Collar 2006
Clicking Shrike-babbler *Pteruthius intermedius aenobarbulus*	split from extralimital taxa	Rheindt & Eaton 2009
Blyth's Shrike-babbler *Pteruthius aeralatus*	split from extralimital taxa	Rheindt & Eaton 2009
Fulvous Parrotbill *Suthora fulvifrons*	generic change from *Paradoxornis*	Yeung *et al.* 2011
Black-throated Parrotbill *Suthora nipalensis*	generic change from *Paradoxornis*	Yeung *et al.* 2011
White-breasted Parrotbill *Paradoxornis ruficeps*	split from regional taxon	King & Robson 2008
Rufous-headed Parrotbill *Paradoxornis bakeri*	split from regional taxon	King & Robson 2008
Indian Grassbird *Graminicola bengalensis*	split from extralimital taxa	Leader *et al.* 2010
Hume's Bush-warbler *Horornis brunnescens*	generic change from *Cettia*	Olsson *et al.* 2006
Aberrant Bush-warbler *Horornis flavolivaceus*	generic change from *Cettia*	Olsson *et al.* 2006
Strong-footed Bush-warbler *Horornis fortipes*	generic change from *Cettia*	Olsson *et al.* 2006
Large Bush-warbler *Oligura major*	generic change from *Cettia*	Olsson *et al.* 2006
Grey-sided Bush-warbler *Oligura brunnifrons*	generic change from *Cettia*	Olsson *et al.* 2006
Chestnut-headed Tesia *Oligura castaneocoronata*	generic change from *Tesia*	Olsson *et al.* 2006
Pale-footed Bush-warbler *Urosphena pallidipes*	generic change from *Cettia*	Olsson *et al.* 2006
Korean Bush-warbler *Horornis canturians*	generic change from *Cettia*	Olsson *et al.* 2006
Chinese Bush-warbler *Locustella tacsanowskia*	generic change from *Bradypterus*	Alström *et al.* 2011b
Baikal Bush-warbler *Locustella davidi*	split from regional taxa, generic change from *Bradypterus*	Alström *et al.* 2008a; Alström *et al.* 2011b
Spotted Bush-warbler *Locustella thoracica*	generic change from *Bradypterus*	Alström *et al.* 2008a; Alström *et al.* 2011b
West Himalayan Bush-warbler *Locustella kashmirensis*	split from regional taxa, generic change from *Bradypterus*	Alström *et al.* 2008a; Alström *et al.* 2011b
Brown Bush-warbler *Locustella luteoventris*	generic change from *Bradypterus*	Alström *et al.* 2011b
Russet Bush-warbler *Locustella mandelli*	generic change from *Bradypterus*	Alström *et al.* 2011b
Long-billed Bush-warbler *Locustella major*	generic change from *Bradypterus*	Alström *et al.* 2011b
Black-browed Reed-warbler *Acrocephalus bistrigiceps*	to regular list from hypothetical	OBI
Thick-billed Warbler *Phragamaticola aedon*	generic change from *Acrocephalus*	Fregin *et al.* 2009
Booted Warbler *Iduna caligata*	generic change from *Hippolais*	Fregin *et al.* 2009
Sykes's Warbler *Iduna rama*	generic change from *Hippolais*	Fregin *et al.* 2009
Eastern Olivaceous Warbler *Iduna pallida*	generic change from *Hippolais*	Fregin *et al.* 2009
Mountain Tailorbird *Phyllergates cuculatus*	generic change from *Orthotomus*	Olsson *et al.* 2006; Alström *et al.* 2011a
Arctic Warbler *Phylloscopus borealis*	split from extralimital taxa	Alström *et al.* 2011d
Claudia's Leaf-warbler *Phylloscopus claudiae*	split from regional taxa	Olsson *et al.* 2005
Desert Whitethroat *Sylvia minula*	split from regional taxa (questionably)	IOC 2.11
Rufous-vented Tit *Periparus rubidiventris*	generic change from *Parus*	Gill *et al.* 2005
Rufous-naped Tit *Periparus rufonuchalis*	generic change from *Parus*	Gill *et al.* 2005
Coal Tit *Periparus ater melanolophus*	lump with regional taxa, generic change from *Parus*	Gill *et al.* 2005; Eck & Martens 2006
Coal Tit *Periparus ater aemodius*	generic change from *Parus*	Gill *et al.* 2005
Grey-crested Tit *Lophophanes dichrous*	generic change from *Parus*	Gill *et al.* 2005
Cinereous Tit *Parus cinereus*	split from regional taxa	Eck & Martens 2006; Päckert *et al.* 2005
Japanese Tit *Parus minor tibetanus*	split from regional taxa	Eck & Martens 2006; Päckert *et al.* 2005
Great Tit *Parus major bokharensis*	lump with extralimital taxa	Eck & Martens 2006; Päckert *et al.* 2005
Black-bibbed Tit *Poecile hypermelaenus*	split from extralimital taxa, generic change from *Parus*	Gill *et al.* 2005
Marsh Tit *Poecile palustris*	generic change from *Parus*	Gill *et al.* 2005
Willow Tit *Poecile montanus*	generic change from *Parus*	Gill *et al.* 2005
White-browed Tit *Poecile superciliosus*	generic change from *Parus*	Gill *et al.* 2005
Azure Tit *Cyanistes cyanus*	generic change from *Parus*	Gill *et al.* 2005

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Name in 2nd edition	Status change	References/authority followed
Azure Tit *Cyanistes cyanus flavipectus*	generic change from *Parus*	Gill *et al.* 2005
Crested Tit-Warbler *Leptopoecile elegans*	addition	Sangha *et al.* 2007
Red-headed Tit *Aegithalos iredalei*	split from regional taxa	Päckert *et al.* 2010
Black-browed Tit *Aegithalos bonvaloti*	split from regional taxon	Päckert *et al.* 2010
Hodgson's Treecreeper *Certhia hodgsoni hodgsoni/mandellii/khamensis*	split from extralimital taxa	Tietze *et al.* 2006
Manipur Treecreeper *Certhia manipurensis*	split from regional taxa	Tietze *et al.* 2006
Indian Spotted Creeper *Salpornis spilonotus*	split from extralimital taxa	Tietze & Martens 2010
Neglected Nuthatch *Sitta neglecta*	split from regional taxa	IOC 2.11
Thick-billed Flowerpecker *Pachyglossa agilis*	generic change from *Dicaeum*	Nyári *et al.* 2009
Modest Flowerpecker *Pachyglossa obsoleta*	generic change from *Dicaeum*, split from regional taxa	Nyári *et al.* 2009; Rasmussen & Anderton 2012
Yellow-vented Flowerpecker *Pachyglossa chrysorrhea*	generic change from *Dicaeum*	Nyári *et al.* 2009
Yellow-bellied Flowerpecker *Pachyglossa melanoxantha*	generic change from *Dicaeum*	Nyári *et al.* 2009
Legge's Flowerpecker *Pachyglossa vincens*	generic change from *Dicaeum*	Nyári *et al.* 2009
Little Spiderhunter *Arachnothera longirostra*	split from extralimital taxa	Rahman *et al.* 2010
Crested Bunting *Emberiza lathami*	generic change from *Melophus*	Alström *et al.* 2008b
Corn Bunting *Emberiza calandra*	generic change from *Miliaria*	Alström *et al.* 2008b
European Linnet *Linaria cannabina*	generic change from *Acanthis*	Zuccon *et al.* 2012
Twite *Linaria flavirostris*	generic change from *Acanthis*	Zuccon *et al.* 2012
Himalayan Greenfinch *Chloris spinoides*	generic change from *Carduelis*	Zuccon *et al.* 2012
Black-headed Greenfinch *Chloris ambigua*	generic change from *Carduelis*	Zuccon *et al.* 2012
Eurasian Siskin *Spinus spinus*	generic change from *Carduelis*	Zuccon *et al.* 2012
Tibetan Siskin *Spinus thibetanus*	generic change from *Carduelis*	Zuccon *et al.* 2012
European Greenfinch *Chloris chloris*	generic change from *Carduelis*	Zuccon *et al.* 2012
Common Rosefinch *Erythrina erythrina*	generic change from *Carpodacus*	Zuccon *et al.* 2012
Red-fronted Rosefinch *Carpodacus puniceus*	generic change from *Pyrrhospiza*	Zuccon *et al.* 2012
Dark-breasted Rosefinch *Procarduelis nipalensis*	generic change from *Carpodacus*	Zuccon *et al.* 2012
Blanford's Rosefinch *Agraphospiza rubescens*	generic change from *Carpodacus*	Zuccon *et al.* 2012
Long-tailed Rosefinch *Carpodacus sibiricus*	generic change from *Uragus*	Zuccon *et al.* 2012
Crimson-browed Finch *Carpodacus subhimachalus*	generic change from *Propyrrhula*	Zuccon *et al.* 2012
Yellow-throated Sparrow *Gymnoris xanthocollis*	generic change from *Petronia*	IOC 2.11
Black Drongo *Edolius macrocercus*	generic change from *Dicrurus*	Pasquet *et al.* 2007
Ashy Drongo *Edolius leucophaeus*	generic change from *Dicrurus*	Pasquet *et al.* 2007
Bronzed Drongo *Chaptia aenea*	generic change from *Dicrurus*	Pasquet *et al.* 2007
White-bellied Drongo *Edolius caerulescens*	generic change from *Dicrurus*	Pasquet *et al.* 2007
Daurian Starling *Agropsar sturninus*	generic change from *Sturnia*	Lovette *et al.* 2008; Zuccon *et al.* 2008
Brahminy Starling *Sturnia pagodarum*	generic change from *Temenuchus*	Zuccon *et al.* 2008
Vinous-breasted Myna *Acridotheres burmannicus*	generic change from *Sturnia*	Lovette *et al.* 2008; Zuccon *et al.* 2008
Chestnut-cheeked Starling *Agropsar philippensis*	addition	van der Wielen 2007
Rosy Starling *Pastor roseus*	generic change from *Sturnus*	Lovette *et al.* 2008; Zuccon *et al.* 2008
White-faced Starling *Sturnornis albofrontatus*	generic change from *Sturnia*	Lovette *et al.* 2008; Zuccon *et al.* 2008

that they do these provide clear support to the three-way species split. The same is true for, for example, the Andaman Bulbul *Pycnonotus fuscoflavescens*, formerly considered a race of Black-headed Bulbul *P. atriceps*. Even for a species as locally common as the Andaman Scops-Owl *Otus balli*, iris colour had never been reliably recorded, and hence photos of this species now on Oriental Bird Images provided confirmation of this important feature. The few photos of Legge's Hawk-eagle *Nisaetus kelaarti* on OBI provide confirmatory evidence for characters observed on specimens (especially the huge bill and claws). Digital sound archives like AVoCet (Avian Vocalizations Center, at Michigan State University), Xeno-canto, the Internet Bird Collection, and Macaulay Library of Cornell, have provided a great deal of data unavailable by 2005. At that time, the songs of Naga Wren-babbler *Spelaeornis nagaensis*, Cachar Wedge-billed Babbler *Sphenocichla roberti*, and Himalayan Spot-throated Babbler *Pellorneum albiventre* (among others) were entirely unknown, and these have since become available. However, surprisingly there are still South Asian species for which we have little if any good evidence on their vocalisations, such as Painted Spurfowl *Galloperdix lunulata*, Manipur Bush-quail *P. manipurensis*, Speckled Woodpigeon *Columba hodgsoni*, Pale-capped Pigeon *C. puniceus*, Large-billed Ground-thrush *Zoothera monticola*, and Nilgiri Thrush *Z. neilgherriensis*, among others.

Despite all the progress, many South Asian avian mysteries remain, and these involve not just missing species like Himalayan Quail *Ophrysia superciliosa* and Pink-headed Duck *Rhodonessa caryophyllacea*. For example, what is Vaurie's Nightjar *Caprimulgus centralasiae*? Where do Kashmir's Blunt-winged Warbler *Acrocephalus concinens* and Long-billed Bush-Warbler *Bradypterus major* winter? Do species considered hypothetical in Birds of South Asia like Szechenyi's Monal-Partridge *Tetraophasis szechenyii*, Tibetan Eared-pheasant *Crossoptilon harmani*, Derby's Parakeet *Psittacula derbiana*, Elliot's Laughingthrush *Trochalopteron elliotii*, Brown-cheeked Laughingthrush *T. henrici*, and Giant Babax *Babax waddelli*, really occur somewhere in Arunachal Pradesh? The field is wide open, the tools are widely available, and this is a challenge to be answered by the new generation of South Asian field ornithologists.

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ASSESSING THE STATUS AND DISTRIBUTION OF THE GREAT SLATY WOODPECKER *MULLERIPICUS PULVERULENTUS* (TEMMINCK 1826) IN SUB-HIMALAYAN UTTARAKHAND, INDIA

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Owing to its global decline, the Great Slaty Woodpecker *Mulleripicus pulverulentus* has been categorised as Vulnerable by IUCN. In India, the species is rare and occurs in the sub-Himalayan moist tropical forests from Uttarakhand in the west to Arunachal Pradesh in the east. Available records indicate that the Great Slaty Woodpecker (GSW) is dependent upon mature dipterocarp forests. However, there is very little scientific information on its distribution or habitat preferences in India. We surveyed the distribution of GSW and searched for its breeding sites in the Sal forests of western Uttarakhand. Using forest department records, we identified 50 sites having relatively mature Sal forests, which were likely to harbour GSW. At each site we carried out call playback surveys to detect the presence of GSW and qualitatively evaluated forest habitat structure. We detected GSW presence at seven sites, observed breeding at three, and found nesting trees at six sites. GSW was observed mainly in mature Sal-dominated forests in sloping terrain. Most trees in which cavities were found were deformed or diseased and had a median diameter at breast height (DBH) of 53.5 cm. For conserving GSW, it is important that mature Sal stands be retained, and silvicultural removal of deformed trees be discontinued.

Key words: Woodpeckers, Western Himalaya, *Shorea robusta*, cavity-nesters, breeding

INTRODUCTION

Woodpeckers (Family Picidae) are highly sensitive to changes in woody vegetation attributable to anthropogenic causes, including those related to forest management and exploitation (Short and Horne 1990; Winkler *et al.* 1995). Operations like logging, systematic manipulation for forest structure, plantations, and fuel wood extraction are therefore likely to have an impact on the extant woodpecker community (Mikusiñski 2006).

Larger woodpeckers are affected by conventional forestry operations to a much greater degree than smaller ones as large-bodied woodpeckers generally require larger trees for nesting, roosting and foraging, and such trees are usually the first to be harvested in typical silvicultural practices (Short and Horne 1990). They also require larger areas of forest for foraging. Decline of old-growth forests is believed to be the main causative factor for the extinction of two of the world's largest woodpecker species, Imperial Woodpecker *Campephilus imperialis* and Ivory-billed Woodpecker *C. principalis* in the Americas (Short and Horne 1990).

The Great Slaty Woodpecker *Mulleripicus pulverulentus* (Temminck 1826), is the largest in Asia, and perhaps the largest surviving picid in the world. Although this species is distributed widely, extending from Greater Sundas, through Indo-China, Myanmar, SE Bangladesh, Nepal, north-east India and the terai and foothills of India from Arunachal Pradesh to Himachal Pradesh, it is scarce throughout its geographic range (Winkler *et al.* 1995). The Great Slaty Woodpecker inhabits mature dipterocarp forests wherever it exists in the world (Winkler *et al.* 1995). The species breeds cooperatively (Lammertink 2004), and we have observed it in groups of up to 12 individuals.

Like the Imperial and the Ivory-billed, the Great Slaty Woodpecker too has experienced a decline due to logging of primary dipterocarp forests. According to a recent study, the global population of this species has been reduced by as much as 90% during the last 100 years, primarily due to habitat loss to logging (Lammertink *et al.* 2009). Taking note of this finding, the IUCN elevated the threatened status of Great Slaty Woodpecker to Vulnerable in 2010 (BirdLife International 2010).

In India, the Great Slaty Woodpecker is believed to occur in a narrow, discontinuous belt of sub-Himalayan moist deciduous forests (Ali and Ripley 1983), mostly consisting of Sal (*Shorea robusta*), extending from Uttarakhand in the west to Arunachal Pradesh in the east, up to 1000 msl. The species is rare throughout its range. However, it may be seen fairly often at places where it occurs, e.g. in Dudhwa National Park in Uttar Pradesh (D. Mohan, pers. comm.), Corbett Tiger Reserve, Ramnagar and Lansdowne forest divisions in Uttarakhand (authors pers. obs.; Mohan and Kumar 2010). Occasional sightings of the species have been reported from Arunachal Pradesh (R. Naniwadekar and S. Prasad, pers. comm.; P. Singh, pers. comm.). However, no systematic distributional surveys have been undertaken in India.

Sub-Himalayan Uttarakhand forms a significant part of the distribution of GSW because this region forms the northernmost as well as westernmost extent of its distribution.

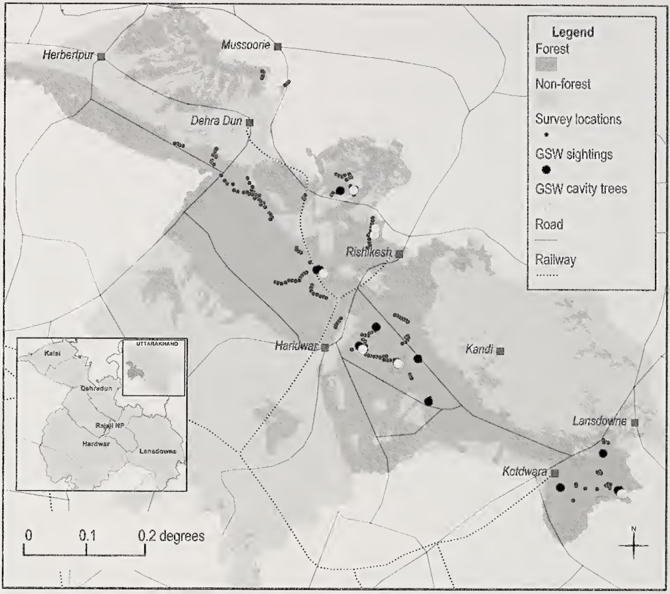
Legend
Forest
Non-forest
Survey locations
GSW sightings
GSW cavity trees
Road
Railway
Herbertpur
Mussoorie
Dehra Dun
Rishikesh
Haridwar
Kandi
Lansdowne
Kotdwara
UTTARAKHAND
Kalsi
Dehradun
Rajaji NP
Hardwar
Lansdowne
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Fig. 1: Location of survey blocks, Great Slaty Woodpecker sightings and cavity trees in the study area. Inset showing major units of forest administration (Forest Divisions) and their location in Uttarakhand

This region is covered by moist deciduous forests dominated by Sal (Champion and Seth 1968). Because of the economic importance of Sal as a source of timber, these forests have been intensively managed for nearly a century. Consequently, the original structure and composition of Sal forests have both been significantly altered. This area is an important repository for biodiversity, as it harbours many species of conservation importance, including Tiger and Asian Elephant, and forms a part of the Terai Arc Landscape (Johnsingh *et al.* 2004). The region is also a vital area for bird diversity that includes 17 species of woodpecker.

Earlier work in the eastern part of sub-Himalayan Uttarakhand (Ramnagar Forest Division and Corbett Tiger Reserve) indicates that the Great Slaty Woodpecker is extremely rare in the region, seen only occasionally in native or managed Sal forest with mature trees (Kumar *et al.* 2011). Kolhu Chaur in Lansdowne forest division was believed to be the westernmost breeding distribution for the species (Ali and Ripley 1883). Although a few stray (unpublished) sightings of the Great Slaty Woodpecker have been reported from the area west of Kolhu Chaur, i.e. Rajaji National Park (A. Harihar, pers. comm.) and Dehradun Forest Division (authors pers. obs.), most of these observations were made during winter when the species is believed to range wider than during the nesting season.

We conducted a study to survey the distribution of Great Slaty Woodpecker in the Sal forests of western Uttarakhand and to search for breeding sites. Through this study, we expected to fill gaps in information about the status of this rare woodpecker, which would be useful in its monitoring and conservation, and would help understand its occurrence in the rest of the sub-Himalayas.

Table 1: Details of locations surveyed, Great Slaty Woodpecker detections, and habitat characteristics

Forest division	Location	No. of playback stations	No. of GSW detection	No. of individuals	No. of GSW cavity trees	Forest composition	Terrain	Forest age
Dehradun	Asarori 1	4	-	-	-	Sal	Flat	Young
Dehradun	Asarori 2	6	-	-	-	Sal	Steep slope	Young
Dehradun	Barkot 1	6	-	-	2	Sal	Flat	Middle
Dehradun	Barkot 2	5	-	-	-	Sal	Flat	Old
Rajaji NP	Ber Sot	5	-	-	-	Sal	Gentle slope	Old
Rajaji NP	Bulindawala 1	4	-	-	-	Sal	Flat	Old
Rajaji NP	Bulindawala 2	5	-	-	-	Sal	Flat	Middle
Dehradun	Chandrabani 1	5	-	-	-	Sal	Flat	Middle
Dehradun	Chandrabani 2	4	-	-	-	Sal	Flat	Middle
Dehradun	Chandrabani WII	4	-	-	-	Sal	Flat	Middle
Lansdowne	Chaukham	5	2	5, 4	2	Sal	Gentle slope	Old
Rajaji NP	Chilla	4	-	-	-	Sal-mixed	Flat	Middle
Lansdowne	Dhimki Hill	5	-	-	-	Sal	Steep slope	Middle
Lansdowne	Dhimki-Nauri 1	4	-	-	-	Sal	Steep slope	Young
Lansdowne	Dhimki-Nauri 2	4	1	1	-	Sal	Steep slope	Middle
Dehradun	Galjwari	4	-	-	-	Sal	Steep slope	Young
Rajaji NP	Ghasiram 1	7	-	-	-	Sal	Steep slope	Middle
Rajaji NP	Ghata 1	3	-	-	-	Sal-mixed	Steep slope	Middle
Rajaji NP	Ghata 2	4	-	-	-	Sal-mixed	Gentle slope	Old
Rajaji NP	Hazara	4	1	3	1	Sal	Gentle slope	Old
Rajaji NP	Jhabrawala	5	-	-	-	Sal	Flat	Middle
Rajaji NP	Jogi Chaur	4	-	-	-	Sal	Flat	Middle
Rajaji NP	Kansrao 1	5	1	3	1	Sal	Flat	Old
Rajaji NP	Kansrao 2	5	-	-	-	Sal-mixed	Gentle slope	Old
Dehradun	Karwapani	4	-	-	-	Sal	Flat	Middle
Rajaji NP	Kauriya	7	-	-	-	Sal	Gentle slope	Old
Rajaji NP	Kharkhari	5	-	-	-	Sal	Flat	Old
Rajaji NP	Koelpura 1	4	-	-	-	Sal	Gentle slope	Young
Rajaji NP	Koelpura 2	4	-	-	-	Sal	Steep slope	Middle
Dehradun	Lachiwala	5	-	-	-	Sal	Flat	Old
Rajaji NP	Mithawali	4	-	-	1	Sal-mixed	Steep slope	Old
Rajaji NP	Mundal	6	-	-	-	Mixed	Steep slope	Middle
Lansdowne	Murakhal	4	-	-	-	Sal	Steep slope	Middle
Lansdowne	North Kotdi 1	2	1	5	-	Sal	Steep slope	Middle
Rajaji NP	Phandowala 1	4	-	-	-	Sal	Flat	Middle
Rajaji NP	Phandowala 2	3	-	-	-	Sal	Flat	Middle
Dehradun	Rajpur	4	-	-	-	Sal	Steep slope	Young
Rajaji NP	Ramgarh	3	-	-	-	Sal	Steep slope	Young
Rajaji NP	Rawasan	4	-	-	-	Mixed	Steep slope	Old
Rajaji NP	Sain Sot 1	3	1	3	3	Sal	Gentle slope	Old
Rajaji NP	Sain Sot 2	3	-	-	-	Sal	Gentle slope	Middle
Rajaji NP	Sarkada	3	-	-	-	Mixed	Gentle slope	Old
Rajaji NP	Soni Sot	5	1	2	-	Sal-mixed	Steep slope	Middle
Lansdowne	South Kotdi 1	2	-	-	-	Sal	Gentle slope	Old
Lansdowne	South Kotdi 2	1	-	-	-	Sal-mixed	Steep slope	Middle
Lansdowne	South Kotdi 3	1	-	-	-	Sal	Steep slope	Middle
Dehradun	Thano 1	4	-	-	-	Sal	Flat	Old
Dehradun	Thano 2	6	-	-	-	Sal	Flat	Middle
Dehradun	Thano Ramnagar	15	-	-	-	Sal	Flat	Old
Dehradun	Thano Ramnagar	26	-	-	1	Sal	Flat	Old

METHODS

Our previous study on woodpecker communities (Kumar *et al.* 2011) as well as published literature from south-east Asia suggests that the Great Slaty Woodpecker was likely to be partial to forests with mature Sal trees. We consulted records of the Uttarakhand Forest Department (i.e., management plans and compartment histories) to identify forest blocks that had older Sal forests, which we expected to potentially support the Great Slaty Woodpecker. Thus, we identified 50 forest blocks in the forest divisions of Lansdowne, Hardwar, Dehradun, Kalsi, and Rajaji National Park (Fig. 1).

At these locations we carried out call playback-assisted surveys to assess the presence of Great Slaty Woodpecker. Woodpeckers, including GSW, exhibit a good response to conspecific call playback in the form of conspicuous visual or aural cues, hence they get detected (Kumar and Singh 2010).

At each location, we selected multiple points to carry out surveys for woodpeckers. Depending on the configuration and terrain, we selected up to seven points at each location but in most cases, we had four to five points per location. At each point, we broadcast the calls of the GSW four times in succession (once in each cardinal direction), interspersed with a 10-second observation interval. The minimum distance between successive points was 400 m, to avoid overlap between the coverage areas of the consecutive broadcast stations.

In conjunction with playback surveys, we qualitatively assessed the forest age (old, medium and young), composition (Sal-dominated vs. mixed) and slope for each location.

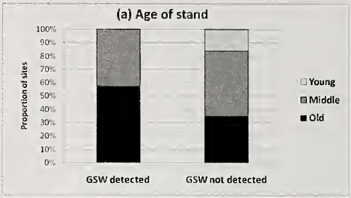
Playback surveys were conducted between May and August 2011. The locations surveyed were distributed over a Sal forest *c.* 100 km long and 35 km wide, oriented in a NW–SE direction. In all, 213 broadcast stations were used to conduct playback (Table 1, Fig. 1).

RESULTS

We sighted the Great Slaty Woodpecker at 7 locations out of the 50 surveyed (Table 1; Fig. 1). The mean group size was 3 and ranged from 1 to 5 individuals.

At four of the locations with Great Slaty Woodpecker sightings, we also encountered trees with nest cavities of the species (Table 1; Fig. 1). Cavity trees were found at four other locations; however, woodpeckers were not sighted at these locations. At some places, we found a cavity tree with other cavity trees in its proximity, suggesting site fidelity for nesting.

Almost all cavity trees had multiple cavities arranged in a vertical formation (Fig. 3). The number of cavities ranged from one to nine in a tree (Table 2). The median DBH (diameter at breast height) of cavity trees was 53.5 cm, suggesting that only mature trees were suitable for excavating cavities. While almost all the cavities were in live trees, it was observed that many of these trees were deformed or otherwise infested (Table 2).



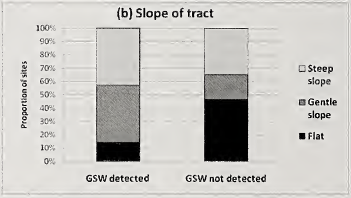


Fig. 2: Habitat characteristics viz. (a) age of stand, and (b) slope of the tract, at sites where Great Slaty Woodpecker was and was not detected. Y-axis indicates proportion of sites

Most of the Great Slaty Woodpecker detections were in old Sal stands and the rest in middle-aged Sal stands. Locations with young Sal did not yield GSW detections, suggesting that young stands are unsuitable (Fig. 2a).

Areas that had Great Slaty Woodpecker detections were mostly on steeply or gently sloping ground (Fig. 2b). The species was seen only in Sal stands and was not seen in mixed forest.

We made detailed observations on two cavity sites used by the Great Slaty Woodpecker. At the first site, which was located in Kotdi Range, Lansdowne Forest Division, we observed that the woodpeckers (seven in all) emerged from their roost/nest cavities a few minutes before dawn and perched on an emergent bare branch of another tree near the cavity tree. This was accompanied by a lot of vocal communication and contact calling. Thereafter, the group dispersed to their foraging grounds in the surrounding Sal forest. At dusk, the group congregated in one or two trees near the cavity tree. This was accompanied by a lot of vocalisation. Then, one by one, the woodpeckers entered their respective cavities, taking

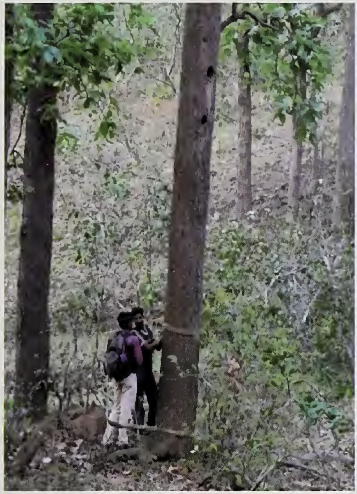


Fig. 3: Photograph showing multiple cavities of Great Slaty Woodpecker in a single tree

up to five minutes to first inspect the cavity before entering it. It was noted that at this time the woodpeckers were extremely cautious and immediately flew away at the slightest disturbance.

At the other cavity tree location in Kansrao Range, Rajaji National Park, we observed a group of three GSWs. A breeding pair was engaged in what was most likely to be incubation, both male and female participating in turns. An incubation session lasted 8–48 minutes, at the end of which the bird that was outside came to the mouth of the cavity and signalled to its incubating mate, who emerged from the cavity. Immediately after emergence, the other replacing individual entered the cavity to assume duty. We observed one more individual, likely to be a helper, in the proximity of the cavity, but it apparently did not participate in incubation duties.

Table 2: Details of Great Slaty Woodpecker cavity trees

Location	Tree species	Tree condition	DBH (cm)	No. of cavities
Chaukham	Sal	Live, broken top	57	3
Chaukham	Sal	Live, broken top	50	4
Hazara	Sal	Live	47	2
Sain Sot	Sal	Live, bent	35	6
Sain Sot	Sal	Live, termite infested	46	8
Sain Sot	Sal	Live	47	8
Kansrao	Sal	Live	67	1
Thano	Sain	Live, slanting	63	9
Barkot	Sain	Live, broken top	61	1
Barkot	Sain	Live	79	1
		Mean (±SD)	55.3 (±12.7)	4.3 (±3.2)

DISCUSSION

Our study has revealed that the Great Slaty Woodpecker is extremely rare in the survey area. However, in most places where the species was detected, we had multiple sightings, which suggests that it can be locally abundant. Further, in some cases, the species was sighted in locations from where it has been reported earlier by naturalists, suggesting a fair degree of nest site fidelity.

The present study found credible evidence of breeding of the Great Slaty Woodpecker nearly 100 km westward of the recorded limit, i.e., Kolhu Chaur. Observations at Kansrao in Rajaji National Park confirm that the species is breeding in the Doon Valley.

Although we did not get adequate data to make conclusive statements on habitat preference, the present study does offer insights into some important factors that may influence the Great Slaty Woodpecker, particularly its breeding. Large trees, snags, and contiguous Sal forest seem to be vital for this species.

Our observations on the cavities of the Great Slaty Woodpecker are a significant addition to the current knowledge about this species. The fact that frequently deformed and infested trees with a median DBH of 53.5 cm are suitable sites for cavity excavation underscores the importance of large, 'imperfect' trees as a breeding requirement of this species. Selective logging, silvicultural operations such as thinning, removal of deadwood and pruning, and conversion of Sal forest to plantations of exotic species, could further endanger this rare species. Finally, our observations on breeding-related activities of the species shed light on the behavioural aspects of this little-known and vulnerable species.

We recommend that the remaining old-growth stands of Sal forest be conserved without silvicultural procedures in order to conserve this species. It is also necessary to consolidate the existing old-growth forest present along the Himalayan foothills by restoring contiguity at the landscape level, possibly through reworking of management plans and initiating restoration activities in the lower Himalaya. This is already happening, since timber extraction has come to a halt and large parts of the area are being prioritised for wildlife conservation. Our study indicates that the GSW could possibly be a flagship species for overall bird diversity in the Terai Arc Landscape. Such linkages could be explored in future research.

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FUNCTIONAL ASSEMBLAGES OF BIRDS IN HETEROGENEOUS LANDSCAPES ALONG AN URBAN-RURAL GRADIENT IN TIRUCHIRAPPALLI, INDIA

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As a result of urbanisation, landscapes and land use patterns are changing the world over. This extreme form of land use alteration has affected species composition and abundance, moulding a few species to dominate the urban environment and a few others to extinction. Urbanisation occurs at different scales and the community composition of species gets affected accordingly. In this paper, we look into species richness and abundance of birds, and their variation along an urban-rural gradient at Tiruchirappalli, India. In Tiruchirappalli, bird species diversity increases from more to less urbanised centres. Though diversity is less in urban areas, the abundance of species occupying these areas is higher. During this study, the maximum recorded birds were omnivores. The most affected species is the House Sparrow, with a few populations residing in the urban environment. Along the urban-rural gradient, farmlands and wetlands are the most preferred landscapes of birds, and conservation measures need to be oriented in this direction to protect the most vulnerable species. Species diversity in urban areas is significantly contributed to by edge species that occupy the fringes of urban areas. Though urban landscapes are less species rich, they too play a significant role in biodiversity conservation as they are species abundant zones. City planners and urban foresters need to pay more attention towards preserving habitats not only in urban areas but along the urban fringes, as they provide suitable corridors for various activities of birds and their movement.

Key words: urbanisation, abundance, richness, homogenization, ecosystem, biodiversity, communities

INTRODUCTION

Urbanisation often modifies landscapes and land use patterns, leading to changes in the vegetation and altering species composition. Urban ecosystems are characterised by low stability, complex and varied dynamics, abundance of exotic species, and different species composition (Machlis *et al.* 1997). Human domination of ecosystems leads to excessive consumption of resources (Turner *et al.* 1991), alteration of habitats and species composition (McKinney 2002), disruption of hydrological processes (Arnold and Gibbons 1996), and modification of energy flow and nutrient cycles (Grimm *et al.* 2000; Vitousek *et al.* 1997). Humans have modified the carbon cycle (Prentice 2001) to an extent that it has lead to the expulsion of large quantities of toxic gases into the atmosphere (Pacyna and Pacyna 2001). Urbanisation drives biotic homogenization (McKinney 2006; McKinney and Lockwood 1999) and it affects the communities found along an urban-rural gradient. When habitat heterogeneity decreases, landscapes often undergo homogenization, and similar species occupy these habitats causing extinction of the endemics (McKinney 2006; Olden 2006).

Studying faunal composition along an urban-rural gradient helps in understanding various ecosystem processes at landscape level. This is a unique area of research. In the concept of an urban-rural gradient, suburban habitats play a unique role in biodiversity conservation. These habitats can be ideal zones for birds and would contain half of the species found in forested areas if they are less exposed to developmental activities (Blair 2004) and high densities of birds in urban areas (Palomino and Carrascal 2006). Species richness peaks at the intermediate level of urbanisation (Tratalos *et al.* 2007). Some species thrive well in areas of high development, but certain other species are sensitive to various stress factors in the environment and are forced to extinction (Jackson 2006). Some prime factors that affect bird community composition and abundance along an urban-rural gradient include proximity to roads, developmental activities (Brotons and Herrando 2001; Fraterrigo and Wiens 2005; Glennon and Porter 2005), and density of buildings (Fraterrigo and Wiens 2005; Friesen *et al.* 1995). Landscape modification and diversity of habitats for various life forms, makes urban areas a priority area for conservation (Miller and Hobbs 2002).

MATERIAL AND METHODS

Study Area

Tiruchirappalli, one of the southernmost cities of India, is a historical city. With an area of 4,404 sq. km, it is the fourth largest city in Tamil Nadu, located at the geographic

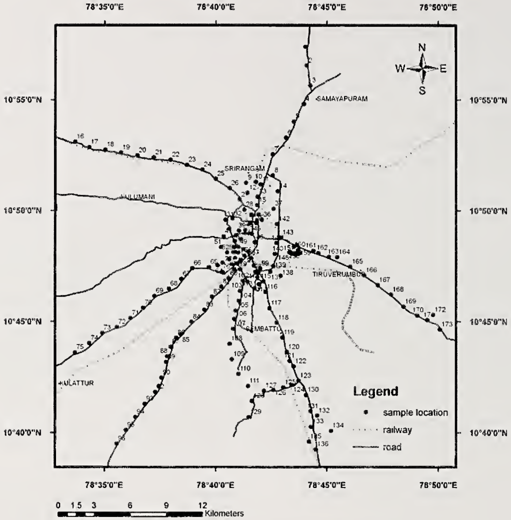

Fig. 1: Sampling points along an urban-rural gradient

centre of the state (10°-11°30' N; 77°45'-78°50' E). The population of the city in 2009 was 829,537. The city lies along the rivers Cauvery and Coleeron, witnessing a high rate of urban agglomeration. It has a number of disconnected hills, among which Pachamalai Hill is the most important, located in the Sengattupatti reserve. The district is agriculturally rich due to its fertile land and perennial rivers. The vegetation is mainly Tropical Dry Deciduous forest and Tropical Thorn forest. The River Cauvery with its numerous distributaries enables extensive paddy cultivation throughout the year. Tiruchirappalli is also among the important industrial cities in Tamil Nadu, with BHEL and HAPP as the major manufacturing units. It is also a major pilgrimage destination with centuries old temples being the major attraction for tourists and a unique habitat for a large number of resident birds. Urbanisation and industrialisation have triggered infrastructure expansion, mushrooming of residential complexes and other commercial developments, leading to large-scale landscape alterations, including changes in seasonal wetlands. These altered landscapes are likely to mould bird species composition and their habitats.

Methodology

Sampling was carried out from October 2010 to September 2011, through 151 point counts to study the effect of landscape changes on species richness and abundance of birds. Sampling points were selected within the city and along the urban-rural gradient. 80 sampling points were selected in the urban, 17 in the suburban and 54 in the rural matrix. At each point, birds were identified and enumerated within 25 m radius for 10 minutes, by the point count method (Bibby *et al.* 2000). The sampling points were visited from 06:00 to 09:00 hrs every month to record bird abundance and richness. All the sampling points within the urban boundary were at distances of 500 m, while along the urban to rural gradient, they were located at a distance of 800 m to 1 km. The points were marked using GPS on eight different roads diverging from the city covering a total area of 900 sq. km (Fig. 1). Survey was avoided on rainy and windy days. The bird species recorded were divided into six foraging guilds: carnivore, granivore, frugivore, insectivore, omnivore, and nectarivore. To evaluate how habitat fragmentation in the urban areas and along the urban-rural gradient affected species composition, bird

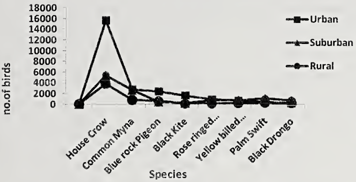

Fig. 2: Species abundance along an urban-rural gradient

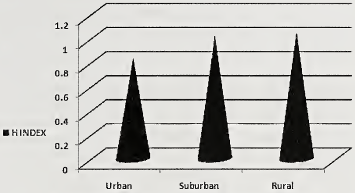

Fig. 3: Diversity index along an urban-rural gradient

community structure and taxonomic composition was studied in various landscapes, like commercial, residential, commercial-residential, agriculture, wastelands, wetlands, and plantations.

Data Analysis

Shannon Wiener species diversity index (Magurran 2004) was calculated within various urban landscapes along the gradient. Niche breadth was calculated to find out the range of resources utilised along the axis (Morin 1999). Species richness, species abundance (Fig. 2), and species evenness were also calculated for different landscapes. The similarity of bird assemblages occupying different landscapes was quantified by Percent of Similarity given by Bray and Curtis (1957). ANOVA recorded the significant difference in diversity indexes of species occupying different landscapes.

RESULTS

A total of 140 species, belonging to 59 families, were recorded during the study with a pooled diversity index of H' = 0.9 (Table 1). The diversity index of rural locations was higher followed by suburban and urban (Fig. 3). The results showed significant difference in the diversity indexes of species occupying the urban-rural gradient (F = 36.76, P = 0.000). Niche breadth did not vary significantly along the gradient (F = 1.43, P = 0.239). Classification of birds based on their trophic status showed a higher density of omnivores (43%) occupying the urban matrix, followed by carnivores (25%), insectivores (17%), nectarivores (8%), granivores (2%), and frugivores (1%). The omnivorous species that were abundant in urban areas were *Milvus migrans*, *Turdoides affinis*, and *Corvus splendens*.

Table 1: Comparison of different indices between urban, suburban, and rural landscapes

Landscapes	Diversity Index	Species Richness	Niche breadth	Species Evenness
Urban	0.82	67	0.22	0.66
Suburban	1.02	85	0.10	0.70
Rural	1.08	137	0.20	0.75

Species richness varied from urban to rural locations, being the highest in the rural matrix (137 species), followed by suburban (85 species), and urban (67 species). The percentage of taxonomic similarity between species occupying the urban and rural landscapes is the lowest at 59%; 72% between urban and suburban; and 63% between suburban and rural.

Along the urban-rural gradient, agricultural landscapes and wetlands are the most preferred habitat for birds, and Eucalyptus plantations are the least preferred. In urban areas, higher abundance of birds was found in locations that had a matrix of residential-commercial land use, rather than purely residential or purely commercial. Agricultural landscapes recorded higher density of insectivores, and wetlands were dominated by Ardeidae species, such as Pond herons (*Ardeola grayii*) and egrets (*Egretta intermedia*, *Egretta garzetta*, and *Bubulcus coromandus*). Diversity index was highest during the southwest monsoon in all landscapes, as seasonal wetlands harbour large numbers of species during the monsoon (Fig. 4). Native tree species *Azadirachta indica*, *Tamarindus indica*, *Ficus benghalensis*, and *Ficus religiosa* were found to harbour a large number of bird species in the urban areas, and shrubs *Prosopis juliflora* and the reed *Typha* provide good habitat

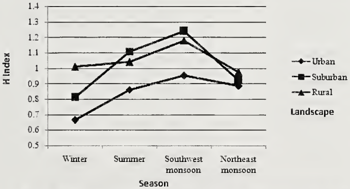

Fig. 4: Scale of diversity among seasons in different landscapes

Table 2: List of bird species recorded based on their foraging guild

Species	Family	Foraging Guild
Accipiter badius	Accipitridae	Carnivore
Accipiter nisus	Accipitridae	Carnivore
Acridotheres tristis	Sturnidae	Omnivore
Acrocephalus agricola	Acrocephalidae	Insectivore
Acrocephalus dumetorum	Acrocephalidae	Insectivore
Actitis hypoleucos	Scolopacidae	Carnivore
Aegithina tiphia	Aegithinidae	Insectivore
Alauda gulgula	Alaudidae	Omnivore
Alcedo atthis	Alcedinidae	Carnivore
Amaurornis phoenicurus	Rallidae	Omnivore
Ammomanes phoenicura	Alaudidae	Insectivore
Anas platyrhynchos	Anatidae	Omnivore
Anas poecilorhyncha	Anatidae	Granivore
Anas querquedula	Anatidae	Carnivore
Anas strepera	Anatidae	Granivore
Anastomus oscitans	Ciconiidae	Carnivore
Anthus richardi	Motacillidae	Insectivore
Anthus rufulus	Motacillidae	Insectivore
Apus nipalensis	Apodidae	Insectivore
Egretta alba	Ardeidae	Carnivore
Ardea cinerea	Ardeidae	Carnivore
Ardea purpurea	Ardeidae	Carnivore
Ardeola grayii	Ardeidae	Carnivore
Artamus fuscus	Artamidae	Insectivore
Athene brama	Strigidae	Carnivore
Bubulcus coromandus	Ardeidae	Carnivore
Butorides striata	Ardeidae	Carnivore
Calandrella brachydactyla	Alaudidae	Insectivore
Caprimulgus asiaticus	Caprimulgidae	Insectivore
Hirundo daurica	Hirundinidae	Insectivore
Centropus bengalensis	Cuculidae	Omnivore
Centropus sinensis	Cuculidae	Carnivore
Ceryle rudis	Ceryiidae	Carnivore
Charadrius dubius	Charadriidae	Carnivore
Ciconia episcopus	Ciconiidae	Carnivore
Cinnyris asiaticus	Nectariniidae	Nectarivore
Circus macrourus	Accipitridae	Carnivore
Cisticola juncidis	Cisticolidae	Insectivore
Clamator jacobinus	Cuculidae	Omnivore
Columba livia	Columbidae	Omnivore
Copsychus saularis	Muscicapidae	Omnivore
Coracias benghalensis	Coraciidae	Omnivore
Coracina melanoptera	Campephagidae	Insectivore
Corvus macrorhynchos	Corvidae	Omnivore
Corvus splendens	Corvidae	Omnivore
Cuculus micropterus	Cuculidae	Omnivore
Cypsiurus balasiensis	Apodidae	Insectivore
Dendrocitta vagabunda	Corvidae	Omnivore
Dendrocygna javanica	Cuculidae	Granivore
Dicaeum agile	Dicaeidae	Nectarivore
Dicaeum erythrorhynchos	Dicaeidae	Nectarivore
Dicaeum minullum	Dicaeidae	Nectarivore
Dicrurus aeneus	Dicruridae	Omnivore
Dicrurus caerulescens	Dicruridae	Insectivore
Dicrurus macrocercus	Dicruridae	Omnivore
Dinopium benghalense	Picidae	Omnivore
Egretta garzetta	Ardeidae	Carnivore
Elanus caeruleus	Accipitridae	Carnivore
Eremopterix griseus	Alaudidae	Carnivore
Eudynamys scolopaceus	Cuculidae	Omnivore
Euodice malabarica	Estrildidae	Granivore
Francolinus pictus	Phasianidae	Omnivore
Francolinus pondicerianus	Phasianidae	Omnivore
Fulica atra	Rallidae	Omnivore
Galerida cristata	Alaudidae	Insectivore
Gallicrex cinerea	Rallidae	Omnivore
Gallinula chloropus	Rallidae	Omnivore
Gelochelidon nilotica	Sternidae	Carnivore
Gracupica contra	Sturnidae	Omnivore
Halcyon smyrnensis	Halcyonidae	Carnivore
Haliastur indus	Accipitridae	Omnivore
Hierococcyx varius	Cuculidae	Carnivore
Himantopus himantopus	Recurvirostridae	Carnivore
Hirundo rustica	Hirundinidae	Insectivore
Hydrophasianus chirurgus	Jacanidae	Omnivore
Ixobrychus cinnamomeus	Ardeidae	Carnivore
Lanius cristatus	Laniidae	Insectivore
Leptocoma zeylonica	Nectariniidae	Nectarivore
Lonchura atricapilla	Estrildidae	Granivore
Lonchura punctulata	Estrildidae	Granivore
Lonchura striata	Estrildidae	Granivore
Megalaima haemacephala	Megalaimidae	Omnivore
Megalurus palustris	Locustellidae	Insectivore
Merops leschenaulti	Meropidae	Insectivore
Merops orientalis	Meropidae	Insectivore
Merops philippinus	Meropidae	Insectivore
Egretta intermedia	Ardeidae	Carnivore
Metopidius indicus	Jacanidae	Carnivore
Milvus migrans	Accipitridae	Omnivore
Mirafra affinis	Alaudidae	Insectivore
Mirafra cantillans	Alaudidae	Insectivore
Mirafra erythroptera	Alaudidae	Insectivore
Motacilla cinerea	Motacillidae	Carnivore
Motacilla madaraspatensis	Motacillidae	Insectivore
Muscicapa dauurica	Muscicapidae	Insectivore
Mycteria leucocephala	Ciconiidae	Carnivore
Cinnyris lotenius	Nectariniidae	Nectarivore
Nycticorax nycticorax	Ardeidae	Carnivore
Oriolus oriolus	Oriolidae	Omnivore
Orthotomus sutorius	Cisticolidae	Insectivore
Passer domesticus	Passeridae	Granivore
Pavo cristatus	Phasianidae	Omnivore
Pericrocotus cinnamomeus	Campephagidae	Insectivore
Phalacrocorax carbo	Phalacrocoracidae	Carnivore
Phalacrocorax fuscicollis	Phalacrocoracidae	Carnivore
Phalacrocorax niger	Phalacrocoracidae	carnivore
Phylloscopus affinis	Phylloscopidae	Insectivore
Phylloscopus fuscatus	Phylloscopidae	Insectivore
Phylloscopus trochiloides	Phylloscopidae	Insectivore
Plegadis falcinellus	Threskiornithidae	Carnivore
Ploceus philippinus	Ploceidae	Omnivore
Porphyrio porphyrio	Rallidae	Carnivore

Table 2: List of bird species recorded based on their foraging guild (*contd.*)

Species	Family	Foraging Guild
Porzana fusca	Rallidae	Omnivore
Prinia inornata	Cisticolidae	Insectivore
Prinia socialis	Cisticolidae	Insectivore
Psittacula krameri	Psittacidae	Frugivore
Pycnonotus cafer	Pycnonotidae	Omnivore
Pycnonotus luteolus	Pycnonotidae	Omnivore
Recurvirostra avosetta	Recurvirostridae	Carnivore
Saxicola caprata	Muscicapidae	Insectivore
Saxicoloides fulicatus	Muscicapidae	Omnivore
Streptopelia chinensis	Columbidae	Omnivore
Sterna hirundo	Sternidae	Carnivore
Streptopelia senegalensis	Columbidae	Omnivore
Streptopelia decaocto	Columbidae	Granivore
Streptopelia orientalis	Columbidae	Omnivore
Temenuchus pagodarum	Sturnidae	Omnivore
Sturnus roseus	Sturnidae	Omnivore
Surniculus lugubris	Cuculidae	Omnivore
Tachybaptus ruficollis	Podicipedidae	Carnivore
Tephrodornis pondicerianus	Prionopidae	Insectivore
Terpsiphone paradisi	Monarchidae	Insectivore
Tringa stagnatilis	Scolopacidae	Insectivore
Turdoides affinis	Timaliidae	Omnivore
Tyto alba	Tytonidae	Carnivore
Upupa epops	Upupidae	Omnivore
Vanellus indicus	Charadriidae	Carnivore
Vanellus malabaricus	Charadriidae	Carnivore
Zoothera citrina	Turdidae	Omnivore

for *Prinia socialis*, *Phylloscopus trochiloides*, *P. affinis*, *Orthotomus sutorius* and *Streptopelia chinensis*.

Along the urban matrix, species concentrate more in the urban fringe as it provides a unique corridor and varied landscapes for different species of birds. Among urban birds, the House Sparrow *Passer domesticus* was the most effected by urbanisation. House Sparrow populations were recorded in 12 urban (Fig. 4), 4 suburban and 20 rural locations. The highest population of House Sparrow was recorded in the suburban regions of Tiruchirappalli, in and around areas of Panjapur along the Madurai bypass. Along the gradient, House Sparrows were mostly seen associated with houses with tiled and thatched roofs, in and around rice mills and agricultural landscapes. The mean population of House Sparrow recorded was urban 9, suburban 114, and rural 36.

DISCUSSION

The results show significant difference in the diversity indexes of species occupying the urban-rural gradient. This

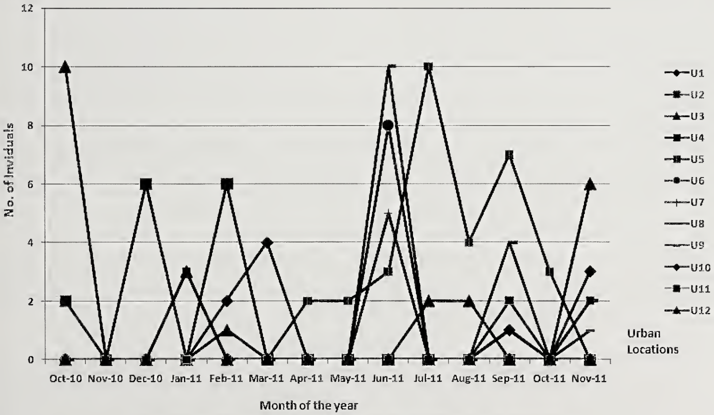

Fig. 5: House Sparrows inhabiting 12 selected locations within the urban landscape

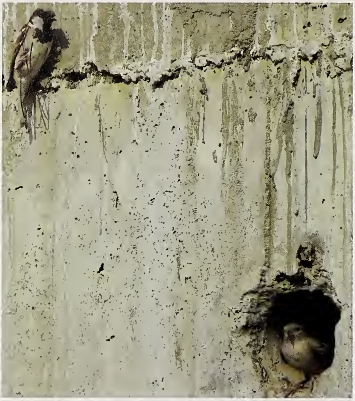

Fig. 6: Nesting of House Sparrows in holes in walls of highway flyovers

can be attributed to the varied landscapes and land use patterns available to birds including agriculture fields, wetlands, wastelands, and plantations. Though diversity is less in urban areas, the abundance of species occupying the urban matrix is higher and increases with urbanisation and is in accordance with other studies (Beissinger and Osborne 1982; Chace and Walsh 2006; Clergeau *et al.* 1998; Emlen 1974; Shochat 2004). Omnivorous species show higher abundance in the urban matrix, leaving less resources to birds from other foraging guilds. Diversity reached a peak at moderate levels of urbanisation and this was revealed in other studies (Blair 1996; 2001; Crooks *et al.* 2004; Jokimäki and Suhonen 1993). But, there was no significant difference in niche breadth of birds occupying different landscapes along an urban-rural gradient, as species tend to exploit a wider area based on resource availability in the urban, suburban, and rural regions. Higher abundance of omnivorous species in urban settings can be correlated to the abundant resources and less predation in the urban matrix, which is supported by several studies (Beissinger and Osborne 1982; Chace and Walsh 2006; Emlen 1974; Kluza *et al.* 2000; Lancaster and Rees 1979; Mills *et al.* 1989). Species diversity in the urban landscape is significantly composed by the edge species like Black Drongo, Indian Roller, Indian Pond-Heron, Great Egret, Little Egret, Eastern Cattle-Egret, Indian Bush Lark that occupy the urban fringes. This study proves that urbanisation has a negative impact on species richness, and is supported by other studies by Stratford and Robinson (2005).

Among the common urban birds, *Passer domesticus* is the most affected, with only a few individuals inhabiting select locations within the city. Their decline can be attributed to loss of food due to modernised granaries, decline of insect prey and most importantly loss of nesting sites. Although decline is noticed overall in the study area, a few sparrow friendly habitats occur along the urban fringes and rural matrix, particularly in the proximity of rice mills, thatched huts, and more interestingly in drainage holes of highway flyovers in the district (Figs 5 & 6). In the district, the highest population of *Passer domesticus* was recorded along the Madurai bypass (Panjapur) and can be attributed to large scale cultivation of paddy and rice mills in the area. Large scale habitat alteration due to changing land use patterns as a result of urbanisation and waning paddy cultivation the world over is a cause of concern for declining House Sparrow populations.

CONCLUSION

In Tiruchirappalli, bird species diversity increases from more to less urbanised centres (Clergeau *et al.* 1998; McKinney 2002). Though urban landscapes are less species diverse, they too play a crucial role in conserving biodiversity as they are 'Species Abundant Zones'. City planners and urban foresters should incorporate the concept of 'Urban Bird Reserve' along urban fringes into urban landscape planning. Protecting the green cover, conserving water bodies, preserving dead trees, constructing ecofriendly architecture, and well-designed urban landscaping will help in protecting and reversing the decline of urban bird species.

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AVAILABILITY OF NESTING HABITAT MAY NOT DRIVE COLONY FORMATION IN CHESTNUT-HEADED BEE-EATERS *MEROPS LESCHENAULTI* IN SOUTHERN INDIA

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Colonial breeding may be driven by patchy breeding habitats leading to congregation of individuals at suitable sites, or by conspecific attraction, where individuals choose to nest in the proximity of past or present nesting sites of conspecifics. The selection of habitat might also be influenced by age and body condition. Chestnut-headed Bee-eaters *Merops leschenaulti* (CHB) breed solitarily and in small colonies. Data on nesting pairs and nests were collected over five months from December 2010 to May 2011 during the breeding season in Haliyal and Karwar Forest Division, Uttara Kannada district, Karnataka. A total of 17 nests were found during the course of the study, distributed in three colonies and five solitary nesting sites. We measured and compared habitat characteristics of nests at solitary and colonial breeding sites and found no significant difference between habitat characteristics at solitary and colonial nests. We also found that colonial nesting birds were slightly larger than solitary ones. There is some evidence pointing at despotism and the role of the previous year's nest holes in CHB nesting behaviour, and further investigations are required to validate the hypothesis.

Key words: Group breeding, Conspecific attraction, tarsus length, traditional aggregation, Western Ghats

Breeding in densely distributed territories that contain no other resources apart from breeding sites is known as colonial breeding (Perrins and Birkhead 1983). Colony size shows a wide variation in many species, for example, in Bank Swallow *Riparia riparia* colony size ranges from two breeding pairs to several hundred pairs (Hoogland and Sherman 1976). This plasticity in colony size is especially remarkable, considering that there is high selection pressure on breeding behaviour (Brown *et al.* 1990; Brown and Brown 2001).

Variation in colony size, it was proposed, is a by-product of the process of colony formation involving selection of similar 'commodity' by individuals (Danchin and Wagner 1997). Habitat availability was found to be the main 'commodity' influencing the pattern of colony size variation in many species, for example, in burrowing Alcids (Kaiser and Forbes 1992) and Barn Swallow (*Hirundo rustica*) (Safran 2004). In such cases, colony formation is said to be habitat-mediated, which implies that colony size varies according to the abundance and distribution of resources (Danchin and Wagner 1997).

In many other species, colony formation is conspecific-mediated and additive aggregation of animals is observed, i.e. density of animals might be lower or higher than is expected based on habitat availability (Danchin and Wagner 1997). In such species, colonies may be maintained due to the social benefits of group breeding (Safran *et al.* 2007). Variation in either habitat quality or quantity can influence colony formation. If variation in habitat quality is responsible for colony formation, then the habitat characteristics of sites having solitary nests must be less suitable for breeding than at colony sites. For example, Kaiser and Forbes (1992) showed that colonies of four burrow-nesting Alcids, i.e. Ancient Murrelet *Synthliboramphus antiquus*, Cassin's Auklet *Ptychoramphus aleuticus*, Rhinoceros Auklet *Cerorhinca monocerata* and Tufted Puffin *Fratercula cirrhata*, occur only on less than 2% of the 6,500 islands surveyed and 12 of the largest colonies contained about 83% of the breeding population. They found that occupied islands were located in colder, more saline water, and were subject to less intense rainfall than unoccupied islands.

However, if habitat quantity influences colony formation, i.e., there is a shortage of potential breeding sites, then all the breeding sites should be occupied up to their carrying capacity. This implies that the number of nests in a site should be proportional to the amount of substrate available, as was found to be the case in Rainbow Bee-eater *Merops ornatus* (Boland 2004).

The choice of colony size of different individuals may differ based on non-heritable variation, such as size, condition, age, experience and dominance (Ranta and Lindström 1990) or based on heritable variation (Brown and Brown 2000). In Bearded Tit, females associated with colony formation were larger and in better health condition than in

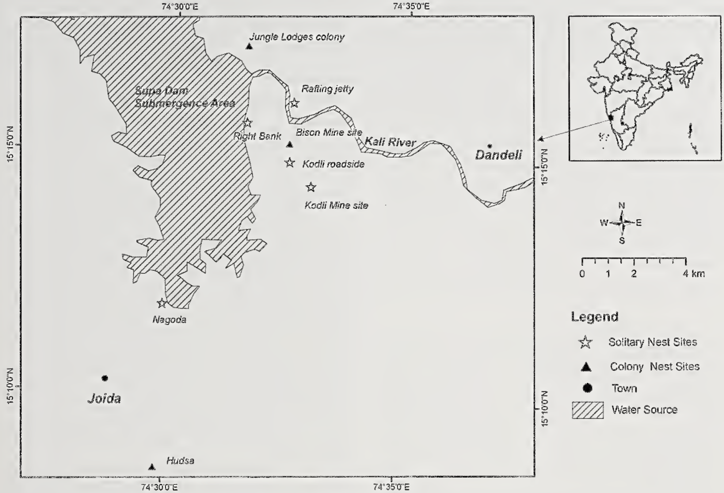

Fig. 1: Study area showing all the nesting sites of Chestnut-headed Bee-eaters found during the study period

solitary nesters (Hoi and Hoi-Leitner 1997). Since morphometric characters reflect the physical condition and the age of the individual, they provide insights into the composition of birds in colony and solitary nest sites.

Chestnut-headed Bee-eaters *Merops leschenaulti* (CHB) are tropical Old World birds (Family Meropidae) that breed both solitarily and in small colonies of 4-8 breeding pairs. Occasionally, large colonies of hundreds of nests have been found (Grimmett *et al.* 1998). CHBs nest in horizontal tunnels up to 2 m long that they dig in sandy banks of streams or on level sandy ground (Ali and Ripley 1970) and on the mudbanks created by road construction. As bee-eaters show wide variation in their social and breeding organisation (Fry 1972), they are appropriate models to investigate how colony formation is influenced by the availability of nesting habitat. A study on colonial breeding in European Bee-eater *Merops apiaster* found a negative relationship between reproductive success and colony size, and suggested that some resource constraints may be responsible for colonial behaviour in their study population (Hoi *et al.* 2002). In the Blue-tailed Bee-eaters *Merops philippinus* breeding in Kinmen Islands, it was observed that many suitable sites were not used and at certain sites, there was high level of clumping (Yuan *et al.* 2006). However, in a recent study, it was found that increasing the amount of substrate available at a nest-site led to an increase in breeding density (Wang *et al.* 2009). Therefore, the evidence for the role of habitat availability in influencing colony sizes is equivocal and studies on related species with varying degrees of social organization will help us understand the trade-off between habitat availability and conspecific attraction in nest-site selection. This study is an attempt to understand the influence of nesting habitat availability, and examine the composition of colonial and solitary nesting CHB, using their morphometric measurements.

STUDY AREA AND METHODS

The field work was carried out from December 2010 to May 2011, in Haliyal and Karwar Forest Division in Uttara Kannada district, Karnataka (Fig. 1). A total of 17 nests were found during the course of the study. The study area is part of the Western Ghats, with altitude 500-600 m above msl. Soil is deep and loamy, and the forest type is moist deciduous dominated by teak (Champion and Seth 1968).

Table 1: Comparison of habitat characteristics of solitary and colony nests of Chestnut-headed Bee-eaters in Haliyal and Karwar forest divisions, Karnataka (December 2010 to May 2011)

Habitat Characteristic	Colony (n = 12)	Solitary (n = 5)
	Mean (S.D.)	Mean (S.D.)
Soil penetrability (1-20)	10.58 (3.60)	11.10 (4.04)
Slope (in degrees)	70.00 (8.79)	73.00 (7.58)
% Ground vegetation cover	14.17 (19.05)	5.00 (11.18)
Distance to nearest used perch (m)*	2.26 (1.23)	6.43 (2.04)
Height of embankment (m)	2.06 (52.28)	1.72 (1.13)
Height of nest (m)	1.39 (0.63)	1.31(1.46)

* Mann-Whitney U Test: $U = 5.00$, $N1=12$, $N2=5$, one-tailed $P= 0.004$

Local birdwatchers were contacted and information on foraging sites, breeding season and nesting sites of CHB was gathered. Each potential nesting site was visited and checked for evidence of nesting in previous years, and for presence of foraging CHBs. Sites fulfilling either of these conditions were then visited repeatedly to check for CHB breeding activity. Roughly 100 hours were spent searching for nests. There were three colonies (two colonies with three nests each, one with six nests) and five solitary nests (Fig. 1). The maximum distance between two nests in a colony was *c.* 65 m. The maximum 'nearest neighbour distance' for a colony nest was about 34 m and the minimum 'nearest neighbour distance' for a solitary nest was greater than 700 m. The nearest distance between the two colonies was 4,290 m; between solitary nests was 1,139 m; and between a solitary nest and a colony was 723 m. Nests found in this study were located in abandoned mine sites, road banks and sandy banks of the backwaters of a dam.

Based on previous studies on breeding biology and nest site-selection in bee-eaters, the following variables were measured to characterise habitat quality: (i) soil penetrability was measured using a Lang Penetrometer which expresses resistance to penetration in pounds on a scale reading from one to twenty; (ii) slope of the embankment was measured using a plumb line extending from a protractor held inverted; the base of the protractor was aligned parallel to the substrate, the reading to the nearest degree against the plumb line measured the inclination of the embankment; (iii) percent vegetation cover was visually estimated in 0.5 m radius around the nest tunnel entrance; (iv) distance to the nearest used perch was measured with a measuring tape; (v) height of embankment was measured using a Tandem Clinometer cum compass; (vi) bearing of nest tunnel was measured using a compass; (vii) distance of nesting site to the nearest water source was either visually estimated (when the site was adjacent to a water body) or measured using Google Earth™ (Asokan *et al.* 2009; Boland 2004; Heneberg 2009; Yuan *et al.* 2006).

Nesting habitat available was measured using Google Earth™ for nesting sites in abandoned mine sites. For nesting sites on linear structures like roads and banks, nesting area available was obtained by multiplying the length of the continuous stretch having similar vegetation characteristics with the average height of the road cutting.

Eighteen CHBs were captured using mist nets spread over the nest tunnel entrance in the early morning hours (6:00-7:00 hrs) and banded using numbered aluminium rings provided by the Bombay Natural History Society, Mumbai (Appendix 1). Morphometric measurements of bill and tarsus were made using dial vernier callipers (least count: 0.01 mm). Tail length and wing length was measured using a graduated scale and measurements were made to the nearest millimetre. The weight of the birds were measured using a 50 gm spring balance to the nearest 0.1 gm. The techniques detailed in the North American Banders' Manual were followed during capture, banding and measuring (North American Banding Council 2001).

As the sample size was low, we used non-parametric statistical tests. One-tailed Mann-Whitney U-test was used to test whether habitat quality was better at colony nesting sites than at solitary nesting sites. Two-tailed Mann-Whitney U-test was used to test differences in morphological measurements of CHBs in solitary and colonial nesting sites (Siegel and Castellan 1988). All analyses were done using SPSS 16.0 (Norussis 1992).

RESULTS

Mann-Whitney U-test results showed that distance to nearest used perch was significantly greater for solitary nests than colony nests (Table 1). Distance to nearest water source for the three colony sites was 10 m (Hudsa colony), 620 m (Jungle Lodges colony) and 760 m (Bison mine site colony). The mean and standard deviation of bearing of the nest tunnels was 183.64 ±104.25 degrees, n = 17 [n = No. of nests]. Amount of substrate available for the birds showed large variation. The maximum nest density was in Jungle Lodges colony that had three nests in 50 sq. m, the minimum nest density was in Hudsa with three nests in 1,11,840 sq. m. There were a few sites that were apparently suitable for breeding (small openings in the forest with plenty of breeding substrate available) but were not used by CHBs in the study season.

Among the morphological features, only tarsus length differed significantly between colony nesters and solitary nesters (Table 2). The standard deviation in weight, wing length, bill length and tail length was greater in colony nesters than in solitary nesters. Tarsus length and bill depth did not show much difference in standard deviation when compared across solitary and colonial nesters.

DISCUSSION

Though the sample size of the study is too low to make broad inferences, the results may suggest that colony formation was not influenced by either habitat quality or abundance. Among all the variables measured that characterised the quality of the habitat, only distance to nearest used perch site was significantly greater for solitary nests than for colonial nests. However, this difference seems to be an outcome of colonial nesting rather than the cause, as there were other perches available in the areas with solitary nests that could have been used by the bird. One possible reason for this difference could be that the individuals nesting solitarily guard the nest from a greater distance to reduce the chances of being noticed by a predator. Avoiding the nest and staying inconspicuous has been observed to be a nest defence strategy in many bird species (Burhans 2000; McLean 1987). However, the colony nests were conspicuous, so guarding a nest from a distance was probably not advantageous.

The large variation in the ratio of number of nests in an area to the amount of substrate available suggests that sites for nesting were not limiting in the study area. This contrasts with the finding in Rainbow Bee-eater *Merops ornatus*, where the number of nests in a colony was found to be tightly correlated with the amount of cleared ground cover available for nesting (Boland 2004). Even in Blue-tailed Bee-eaters, experimental increase in substrate available resulted in increase in nest density (Wang *et al.* 2009)

One important habitat variable that could not be measured in this study is aerial insect availability. Insect distribution and abundance is influenced by land-use heterogeneity and proximity to water (Brown *et al.* 2002). Both these factors were uniform in all the breeding sites in the study area, and hence, we assumed that the insect availability should be similar in all nesting sites. However, future studies should empirically verify this assumption.

Differential colony size choice by different individuals can mask the influence of habitat in nest-site selection, especially in cases where despotism exists and larger individuals may drive smaller individuals to sub-optimal sites. Since tarsus length does not change after a bird reaches the fledging age, it is considered to be a good measure of body size (Freeman and Jackson 1990). The mean tarsus length was found to be different in colonial nesters and solitary nesters; the colonial nesters being marginally larger. Also, a number of instances of aerial chases were observed in the beginning of the breeding season when nest building had just been initiated, suggesting despotism.

Table 2: Morphometric differences between colony nesting and solitary nesting Chestnut-headed Bee-eaters in Haliyal and Karwar divisions, Karnataka

Morphological feature	Colony (n = 13)	Solitary (n = 4)
	Mean (S.D.)	Mean (S.D.)
Weight (gm)#	27.64 (3.23)	25.75 (1.26)
Wing length (mm)	109.54 (3.15)	110.00 (1.15)
Bill length (mm)	32.34 (1.98)	32.42 (2.99)
Bill depth (mm)	5.66 (0.68)	5.44 (0.76)
Tarsus length (mm)*	14.05 (1.41)	12.02 (1.31)
Tail length (mm)	75.00 (3.65)	73.75 (1.26)

#n=14, for colonial nesters

*Mann-Whitney U Test: $U = 8.00$, $n1=13$, $n2=4$, 2-tailed $p = 0.045$

Morphometric variables that are prone to change after fledging (i.e., wing length, tail length, weight) were found to have greater variation among colonial than solitary nesters (Table 1). One plausible explanation for this is that a colony comprises a population belonging to different age-classes, while individuals of a particular age-class (the age class that is nearest to the population mean) constitute the population that made solitary nests. In White-fronted Bee-eaters *Merops bullockoides* extended family units each consisting of a multi-generation lineage coexisted and formed colonies (Emlen and Wrege 1988). In European bee-eater, breeding among close relatives from different generations has been reported (Lessells *et al.* 1994). The evidence from this study suggests that in CHBs also colony nesters might belong to different age-cohorts probably comprised of related individuals. In a scenario where colonies are formed by related individuals who exclude other individuals from occupying the nest-site, the utilisation of nesting sites need not be in proportion to the habitat available to them.

The choice of nest sites observed in our study population was similar to that found by Yuan *et al.* (2006) in Blue-tailed Bee-eaters, where several suitable nesting sites were not utilised. Unlike in the European Bee-eater (*Merops apiaster*) population studied by Hoi *et al.* (2002), habitat constraints did not drive colony formation in our study population of CHBs. Since the hypothesis that the colonies are formed either due to variation in habitat quantity and/or quality was not supported through this study, the alternative explanation that social benefits might be influencing colony formation in this species, needs to be tested (Alexander 1974; Richner and Heeb 1996; Safran *et al.* 2007).

Thus, colony formation in CHBs may be driven by conspecific attraction and not by habitat-mediated aggregation. Among the conspecific attraction hypotheses, only the traditional aggregation hypothesis and conspecific reproductive hypothesis are likely to apply to bee-eaters. Since, bee-eaters are mostly monogamous and the rate of extra-pair copulation is also low (Fry *et al.* 1992), the hidden-lek hypothesis of colony formation is ruled out. Conspecific reproductive success hypothesis assumes that reproductive success varies across different sites (Danchin *et al.* 1998). In this study population, reproductive success was not found to vary among breeding sites (own published data) and hence conspecific reproductive success could not have acted as a cue for selection of breeding sites. Thus, traditional aggregation seems to be responsible for colony formation in CHBs. The role of previous years' nesting holes (evidence of former presence of conspecifics) as a cue needs to be further examined. All three colony sites and two of the five solitary nests had nest tunnels from previous breeding seasons. Other studies have also reported presence of previous years' nest tunnels at breeding sites in many species of bee-eaters (Burt 2002; Fry *et al.* 1992). The presence of former nesting tunnels in breeding sites could also be attributed to site fidelity shown by bee-eaters. During the study, in two separate instances a breeding pair dug a nest in heap of sand meant for construction work. This offers evidence against the role of site fidelity by CHBs at least for solitary nesters.

Future studies directed at testing the various conspecific attraction hypotheses in CHBs may yield more insights into the evolution of colonial breeding in birds.

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For Appendix 1, see page 36

Appendix 1: Ring numbers and measurements of all the captured birds

	Species	Weight (gm)	Age	Moult	Plumage	Brood	Wing length (mm)	Bill length (mm)	Bill depth (mm)	Tarsus length (mm)	Tail (mm)	Locality	Habitat	Date
AB168951	*Merops leschenaulti*	29	5	1	4	2	107	33.75	6.62	12.92	77	1	1	01-03-2011
AB168952	*Merops leschenaulti*	25	5	1	4	2	109	31.23	5.18	15.14	75	2	2	02-03-2011
No ring	*Merops leschenaulti*	25	5	1	4	2						2	2	02-03-2011
AB168953	*Merops leschenaulti*	27	5	1	4	2	110	32.76	4.88	14.81	73	1	1	04-03-2011
AB168954	*Acrocephalus aedon*											3	3	04-03-2011
AB168955	*Merops leschenaulti*	30	5	1	4	2	109	34.35	6.41	16.2	70	2	2	05-03-2011
AB168956	*Merops leschenaulti*	28	5	1	4	2	112	31.42	6.45	14.54	76	2	2	05-03-2011
AB168957	*Merops leschenaulti*	25	5	1	4	2	110	32.77	6.35	13.45	69	2	2	05-03-2011
AB168958	*Merops leschenaulti*	23	5	1	4	2	111	34.47	5.18	14.91	75	2	2	05-03-2011
AB168959	*Merops leschenaulti*	31	5	1	4	2	108	34.44	5.5	12.78	77	2	2	29-03-2011
AB168960	*Merops leschenaulti*	36	5	1	4	2	111	34.48	6.42	11.32	79	1	2	30-03-2011
AB168961	*Merops leschenaulti*	27	5	1	4	2	117	31.25	5.26	15.1	82	2	2	08-04-2011
AB168962	*Merops leschenaulti*	26	5	1	4	2	110	30.11	4.78	14.63	77	2	2	08-04-2011
AB168963	*Merops leschenaulti*	28	5	2	2	2	106	28.11	5.15	12.1	71	1	1	09-04-2011
AB168964	*Merops leschenaulti*	27	5	1	4	2	104	31.27	5.34	14.72	74	1	1	18-04-2011
AB168965	*Merops orientalis*	19	5	1	4	2	93	29.47	4.82	10.15	103	4	2	23-04-2011
AB168966	*Merops leschenaulti*	24	5	1	4	2	111	36.8	5.6	13.22	74	5	2	27-04-2011
AB168967	*Merops leschenaulti*	27	5	1	4	2	111	31.45	6.44	12.88	75	6	2	03-05-2011
AB168968	*Merops leschenaulti*	26	5	1	4	2	109	31.42	4.86	11.63	74	7	2	04-05-2011
AB168969	*Merops leschenaulti*	26	5	1	4	2	109	30.02	4.84	10.34	72	8	2	05-05-2011

Age: 1 - Nestling; 2 - Juvenile (first year); 3 - Sub-adult; 4 - Immature; 5 - Adult; 6 - Fullgrown but stage unknown

Moult: 1 - No moult; 2 - Wing moult; 3 - Tail moult; 4 - Wing and tail; 5 - Head; 6 - Body; 7 - Head and body; 8 - General moult

Plumage: 1 - Down; 2 - Juvenile (first year); 3 - Intermediate; 4 - Adult; 5 - Eclipse; 6 - Breeding; 7 - Partial breeding

Brood patch: 1 - absent; 2 - present but details not recorded; 3 - Skin smooth, glossy, free of feathers; 4 - Skin smooth, network of blood vessels noticeable; 5 - Skin thickened, blood vessels not noticeable, fluid layer under epidermis, brood patch resembles a second degree burn; 6 - Skin wrinkled, dried up, begins to form scales; 7 - Skin becomes smooth, feather calami formed, brood patch begins to be covered up

Locality: 1 - Jungle Lodges colony, 2 - Bison mine site colony, 3 - KPC colony, Ganeshgudi, 4 - Kedapani watchtower, 5 - Kodli roadside, 6 - Right Bank, 7 - Nagoda, 8 - Rafting jetty mine site

Habitat: 1 - Edge of moist deciduous forest; 2 - Moist deciduous forest

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POPULATION STATUS OF WHITE-BACKED VULTURE *GYPS BENGALENSIS* AND LONG-BILLED VULTURE *GYPS INDICUS* IN GUJARAT, INDIA

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A state-wide survey of the Critically Endangered White-backed Vulture *Gyps bengalensis* and Long-billed or Indian Vulture *Gyps indicus* in the 26 districts of Gujarat was undertaken from May 29–30, 2010. The survey was carried out throughout the state by hundreds of volunteers and personnel of the State Forest Department to determine the population of the two *Gyps* vulture species in all the districts and regions of the state, and to assess changes in their populations through comparison with the earlier surveys done in 2005 and 2007. Total count method was used, and the counts were made at resting, roosting, feeding, and nesting sites to assess the population size, number of young birds, and the nest-tree availability. The survey resulted in an estimated population of 793 White-backed Vulture (WBV) and 265 Long-billed Vulture (LBV); the identity of 7 individuals was uncertain. When compared with the earlier surveys, it revealed that there has been a 62.9% decrease (-1,342 individuals) in the population of WBV and 29.5% reduction (-111 individuals) in the population of LBV within a time span of 5 years.

Key words: Gujarat, *Gyps bengalensis*, *Gyps indicus*, White-backed Vulture, Long-billed Vulture, population, status

INTRODUCTION

The populations of three species of vultures, i.e., White-backed Vulture (WBV) *Gyps bengalensis*, Long-billed Vulture (LBV) *Gyps indicus*, and Slender-billed Vulture *Gyps tenuirostris*, have been reported to have declined catastrophically in India, Pakistan, and Nepal since the early 1990s (Prakash 1999; Prakash *et al.* 2003; Virani *et al.* 2001), prompting the IUCN to classify their status as Critically Endangered (BirdLife International 2000). The WBV, which often lives in close association with human habitation areas, was described as the commonest vulture during the 1970s to early/mid-1980s. Densities of 12 nests/sq. km were recorded at Keoladeo National Park, Rajasthan, India (Prakash 1999), and there were nearly 3 nests/sq. km in Delhi (Galushin 1971), where flocks of several thousand birds used to be seen at carcass dumping sites. Even in 1985, WBV was regarded as "possibly the most abundant large bird of prey in the world" (Houston 1985). Of the six species of vultures reported from Gujarat (Ali 1996), three are now recognised as *Gyps* species (Rasmussen and Parry 2001). Owing to the drastic decline in population of *Gyps* vultures, especially of WBV and LBV in Gujarat (and elsewhere in India), the Gujarat State Forest Department and GEER Foundation, with the support of various NGOs, nature clubs, ornithologists, and birdwatchers conducted state-wide vulture surveys in 2005, 2007, and 2010 to assess their population and distribution, and to monitor their possible further decline.

STUDY AREA

Gujarat is the westernmost state of the country, with a 1,600 km long coastline. Gujarat can be divided into five regions, namely Kachchh, Saurashtra, North Gujarat, Central Gujarat, and South Gujarat. The northwestern part of the state (i.e., Kachchh) is arid, with less than 500 mm average annual rainfall. Large areas of the state, encompassing Saurashtra (400 mm rainfall), North Gujarat (700 mm rainfall) and Central Gujarat (800 mm rainfall), have a semi-arid climate. The southern part of Gujarat, which is sub-humid to humid, receives comparatively high rainfall, averaging 2,000 mm per annum.

METHODOLOGY

The entire state consisting of 26 districts (Tapti district was formed after the 2007 Vulture Survey) was surveyed for WBV and LBV. As the survey was carried out state-wide, we took support from various NGOs, nature lovers, birdwatchers, and the Gujarat State Forest Department. Survey of such a widespread area also required a pre-survey planning workshop, which was held to decide the survey dates, methodology, data-sheet format, area distribution among the various district coordinators/key persons, team-building and networking. Moreover, to coordinate, orientate and educate the Forest Department staff and other participants (volunteers), a Satellite Communication (SATCOM) session was conducted in which participants received guidance/ suggestions about methodology, data-sheet use, identification of adult and immature vultures, timing of counts. The GEER Foundation prepared and distributed vulture identification brochures to the participants. The brochure contained colour illustrations and important information regarding identification of vultures. The surveys mainly focused on estimating the population of both the *Gyps* species through total count method. Emphasis was on counting vultures at key habitats or sites like '*panjrapols*' (i.e., permanent cattle shelters), well-known roosting sites (including areas with palm trees), and well-known feeding sites (including backyards and dumping areas of '*panjrapol*'). Counts of vultures in flight were usually avoided. Nesting of the vultures could not be surveyed as the nesting phase was over in the majority of study areas during the survey period (i.e., May 29–30, 2010).The data was recorded on a prescribed data-sheet on the species of vultures sighted number of adults, and immature individuals of each species; time and place of sighting (district, taluka, village/ town), and where possible, the name of the locality, activity like feeding, flying, resting, roosting, habitat type, and other information, such as health status of the vultures and disturbances at sites.

RESULTS AND DISCUSSION

Population and Decline in Gujarat

The survey of vultures in 2010 in Gujarat recorded 793 WBV and 265 LBV, revealing a significant decline in especially WBV population when compared to the counts in 2005 (2,135 WBV and 376 LBV) and 2007 (1,147 WBV and 217LBV).

As the count of WBV was 2,135 individuals in 2005 and 793 individuals during the 2010 survey, it can be concluded that there had been a 62.9% decrease in population (-1,342 birds) in a time-span of 5 years (Fig. 1, Table 1). The decrease in population was 30.9% to that counted in 2007 (i.e., 1,147 individuals), a time-span of 3 years. Overall, the decline in WBV population from 2005 to 2010 was at annual average rate of 12.6%. The decline was 23.1 %/ year between 2005 and 2007 and 10.3%/year between 2007 and 2010, suggesting a lower rate of decline in recent years.

The count for LBV was 376 individuals in 2005 and 265 individuals in 2010, suggesting a 29.5% decrease (-111 individuals) in the population over a time-span of 5 years (Fig. 1, Table1). Thus, the decline in population of LBV was much lower than that recorded for WBV (@ 62.9%). The counts also suggest that there has been a rise by 22.1% (i.e., from 217 individuals to 265 individuals) from 2007 to 2010.

Region- and district-wise Population

The survey in 2010 (and in the previous years) in the various regions and districts revealed that in any district, vulture population were usually concentrated in a few areas and localities. The fact that the vultures were not uniformly distributed may be detrimental to their survival, as any habitat-linked factor, epidemic, or other problems in these restricted areas may lead to drastic population decline in the entire district or region.

North Gujarat Region

North Gujarat is largely semi-arid that includes Banaskantha, Gandhinagar, Mehsana, Sabarkantha, and Patan districts. WBV population had increased in North Gujarat region from 71 vultures in 2005 to 80 vultures in 2007 (12.7 % increase); however, it declined to 32 individuals by 2010 (60% decline to 2007 population, and 54.9% decline to

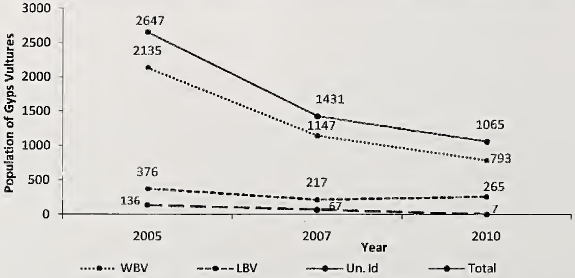

Fig. 1: *Gyps* vulture population trends in Gujarat (2005–2010)

Table 1: District-wise *Gyps* vulture population from 2005 to 2010

Sr. No.	District	Population in 2005			Population in 2007			Population in 2010		
		WBV	LBV	Un id.WBV/ LBV	WBV	LBV	Un id. WBV/ LBV	WBV	LBV	Un id. WBV/ LBV
1	Ahmedabad	254	0	0	279	0	0	224	0	0
2	Amreli	47	0	15	77	0	6	135	0	0
3	Anand	0	0	0	0	0	0	9	2	0
4	Banaskantha	8	0	46	11	0	0	0	3	0
5	Bharuch	42	0	0	0	0	0	0	0	0
6	Bhavnagar	145	3	0	26	1	0	27	0	0
7	Dahod	2	0	0	7	0	12	0	0	0
8	Dangs	8	0	0	0	43	0	0	58	0
9	Gandhinagar	0	0	0	0	0	0	2	0	0
10	Jamnagar	0	0	0	0	0	0	0	0	0
11	Junagadh	44	54	23	0	52	27	14	76	0
12	Kachchh	858	52	0	456	6	0	223	12	0
13	Kheda	0	0	0	0	0	0	0	0	0
14	Mehsana	44	0	0	60	0	0	30	0	0
15	Narmada	0	0	0	0	28	0	7	0	0
16	Navsari	0	0	0	0	0	0	0	0	0
17	Panchmahal	50	107	0	0	11	20	0	19	7
18	Patan	19	1	0	9	0	0	0	0	0
19	Porbandar	0	0	0	0	0	0	0	0	0
20	Rajkot	44	1	0	7	0	0	0	0	0
21	Sabarkantha	0	62	0	0	31	0	0	39	0
22	Surendranagar	272	14	52	80	0	2	6	0	0
23	Surat	273	35	0	135	0	0	94	5	0
24	Tapi	0	0	0	0	0	0	0	0	0
25	Vadodara	25	47	0	0	14	0	0	0	0
26	Valsad	0	0	0	0	31	0	22	51	0
Total	2,135	376	136	1,147	217	67	793	265	7	0

2005 population) – Fig. 2. The LBV population had reduced from 63 vultures to 31 vultures from 2005 to 2007 (50.8% decline), and from 63 vultures to 42 vultures from 2005 to 2010 (33.3% decline), however, there was a rise by 35.5% from 2007 to 2010 (Fig. 2).

Central Gujarat

Central Gujarat is semi-arid, with some hilly tracts in north-eastern districts. Central Gujarat includes six districts, namely Ahmedabad, Anand, Dahod, Panchmahal, Vadodara, and Kheda. WBV population had continuously decreased in Central Gujarat from 331 individuals in 2005 to 286 individuals in 2007 (13.6% decline) and further to 233 individuals in 2010 (29.6% decline to 2005 population and 18.5% decline to 2007 population) (Fig. 3). LBV population had also decreased in Central Gujarat from 154 individuals in 2005 to 25 individuals in 2007 (83.8% decline) and further from 25 individuals in 2007 to 21 individuals in 2010 (16% decline). In a time-span of 5 years (2005 to 2010), the LBV population has declined by 86.4%.

South Gujarat

South Gujarat has a temperate climate with good rainfall, and is characterized by hilly semi-dry-deciduous to semi-evergreen forests. It has seven districts, namely Bharuch, Dangs, Narmada, Surat, Valsad, Tapi, and Navsari. The population of WBV declined from 323 individuals in 2005 to 135 individuals in 2007 (58.2% decline) and further to 123 individuals (8.89% decline) from 2007 to 2010. The overall

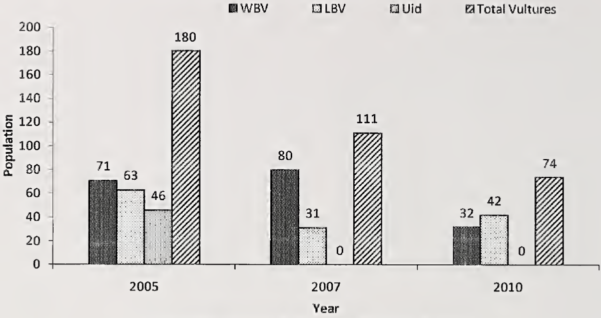

Fig. 2: Population of *Gyps* vultures in North Gujarat (2005–2010)

decline was 61.9% from 2005 to 2010). In contrast, the population of LBV increased from 102 individuals to 114 individuals from 2007 to 2010 (11.8 % increase), and from 35 to 114 individuals from 2005 to 2010 (225.7% population rise) (Fig. 4).

Saurashtra

Saurashtra is a semi-arid region with a long coastal boundary. The region is hilly in central Saurashtra, and has dry-deciduous forests in Gir Sanctuary. The region consists of seven districts, namely Bhavnagar, Amreli, Surendranagar, Junagadh, Porbandar, Rajkot, and Jamnagar. WBV population decreased from 552 individuals in 2005 to 190 individuals in 2007 (65.6 % decline) and further to 182 individuals in 2010 (67% decline to 2005 population and 4.2% decline to 2007 population) – Fig. 5. LBV population decreased from 72 individuals in 2005 to 53 individuals in 2007 (26.4% decline). However, it increased from 53 individuals in 2007 to 76 individuals in 2010 indicating a 43.4% population rise. Over a time-span of 5 years (2005 to 2010), the LBV population had increased by 5.6%.

Kachchh

Kachchh is among the largest districts of India and has an area of 45,652 sq. km. It is semi-arid to arid, and is characterised by a saline desert area known as the 'Rann'. The region consists of one district, i.e., Kachchh. WBV population decreased from

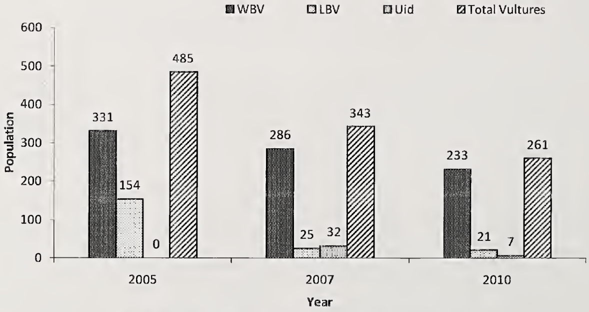

Fig. 3: Population of *Gyps* vultures in Central Gujarat (2005–2010)

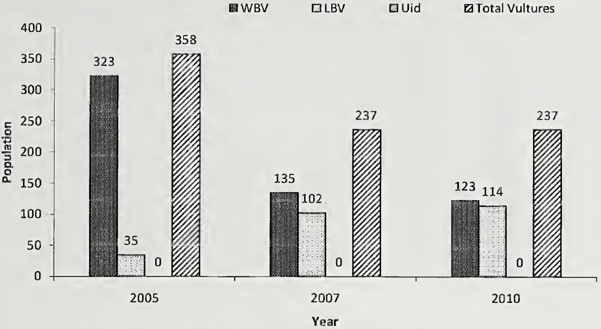

Fig. 4: Population of *Gyps* vultures in South Gujarat (2005–2010)

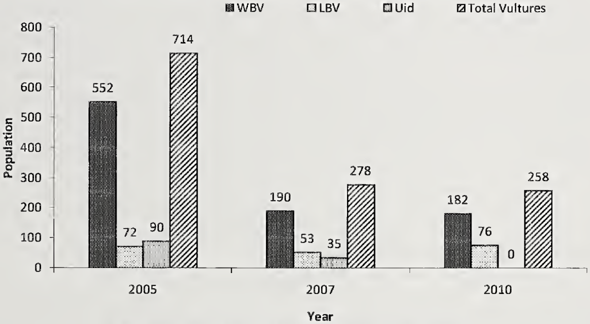

Fig. 5: Population of *Gyps* vultures in Saurashtra (2005–2010)

858 individuals in 2005 to 456 individuals in 2007 (46.8% decline) and further to 223 individuals in 2010 (74% decline to 2005 population and 51.1% decline to 2007 population) (Fig. 5). LBV population decreased from 52 individuals in 2005 to 6 individuals in 2007 (88.5 % decline). However, it increased from 6 individuals in 2007 to 12 individuals in 2010 indicating a 100% population rise. Overall, the population increased by 76.9% from 2005 to 2010.

CONCLUSION

The findings of the three surveys carried out from 2005 to 2010 revealed that the vulture population of WBV and LBV are still on the decline in Gujarat, and the decline is especially steep in the case of the WBV. The WBV has declined by 62.9% from 2005 to 2010 and the LBV by 29.5% for the same period – their populations in Gujarat were 793 and 265 respectively, as per the 2010 census. The findings also revealed that the decline has been less sharp from 2007 to 2010 than from 2005 to 2010, and in fact, there had been a slight increase in population of the LBV from 2007 to 2010. The likely reason for the sharper decline in the population of WBV than LBV is because the latter usually nests in hills on rocky cliff faces, and additionally, in forested areas in the districts of Dangs, Sabarkantha, and Panchmahal. The nesting locations, usually being away from human-dominated areas and away from predators, may possibly be subjected

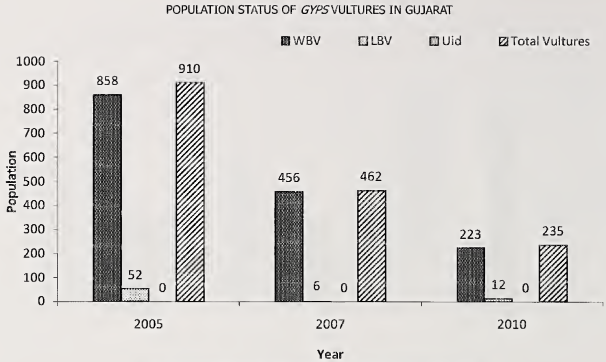

Fig. 6: Population of *Gyps* vultures in Kachchh (2005–2010)

to little or no disturbance during nesting, ensuring greater nesting success and increase in populations. Their less dependence on trees (nests more on crags in the hills) as a nesting substrate may also be another reason for greater nesting success. In contrast, the WBV nests only in trees, and the loss of trees due to cutting or lopping and other disturbances and pressures in human-dominated landscape affect its nesting success.

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CONSERVATION BREEDING FOR THE FUTURE RELEASE OF THE CRITICALLY ENDANGERED ASIAN *GYPS* VULTURES – PROGRESS OF THE PROGRAMME IN SOUTH ASIA AND WHY IT IS SO IMPORTANT

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Three South Asian *Gyps* vulture species are Critically Endangered with extinction, despite having been abundant in the 1990s. The main cause of the declines is now established, being ingestion of a veterinary painkiller, diclofenac, from cattle carcasses, which is toxic to the vultures. Two key actions have been identified by the range state governments and IUCN, namely the eradication of diclofenac from the environment and establishing a conservation breeding and release programme. The Bombay Natural History Society (BNHS) was the first to take up the challenge for India with support from the Partners of the new consortium, Saving Asia's Vultures from Extinction (SAVE). Further programmes are developing for one species in Nepal and Pakistan, which are also integrated through SAVE, and with the support of Central Zoo Authority (CZA), there is progress with additional facilities within India. The breeding programme is most advanced at the BNHS centres, and has already achieved successful breeding of all three species at the centre in Pinjore, Haryana. Artificial incubation techniques have also been developed at the Pinjore centre, with successful rearing, and most recently, allowing some pairs to double productivity by producing two nestlings to fledging within a season, despite the vultures' normal habit of laying one clutch per year. The total number of birds held in all centres combined for all three species combined is 270 in India, with a further 60 in Nepal, and 20 in Pakistan. The Central Zoo Authority supported centres hold additional birds to those held in India.

Key words: vultures, breeding programme, artificial incubation, diclofenac

INTRODUCTION

Why a breeding programme was needed

The scale and speed of declines of three *Gyps* vulture species: White-backed or Oriental White-rumped *Gyps bengalensis*, Long-billed or Indian *G. indicus*, and Slender-billed *G. tenuirostris* across South Asia (Prakash *et al.* 2003) was largely unprecedented for such widespread and formerly abundant bird species, and although the reaction to overcome the established main cause of the declines – the veterinary use of diclofenac – has also been relatively fast (Pain *et al.* 2008), there was no guarantee that these measures could or would take effect in time to prevent the extinction of these species. With this speed and uncertainty in mind, the precaution of taking viable numbers of these species into captivity was agreed in 2004 as a key element of the Recovery Plan [ISARPW (2004); IUCN (2012); MoEF (2006)]. At this time, with the declines still continuing at up to 45% per year in one of the species (Prakash *et al.* 2007) and knowing that extremely low levels of diclofenac remaining in the system would still cause population trends to continue to decline towards extinction (Green *et al.* 2004), all precautions needed full consideration. So while source populations were still available in the wild, birds of all three species were collected from as wide a range of potential sources as was feasible, and with custom-built facilities and expertise from related species available, the prospect for conservation breeding and ultimately reintroduction of the birds was agreed to be a necessary and viable prospect.

The question of whether the methodology would be sufficiently feasible to develop was addressed and heavily influenced by the recent success of the California Condor programme in USA, but perhaps even more so, by the success of programme for the more closely related *Gyps* vulture, the Eurasian Griffon *Gyps fulvus* in Europe. It still required enormous care to minimise any risks involved in capture, housing and providing breeding conditions sufficiently free of disturbance or risks of food contamination (not least from diclofenac), as well as the need to bring a wide range of concerned bodies together to help authorise and agree on this course of action.

Fortunately, there was Government and state government support, as well as sufficient funding from a range of sources to allow progress and in time to build up the stock of birds across all five centres (Table 1). The chronology of these centres varies, and the growing breeding success largely reflects the timing of establishment of each one.

Establishment and progress of the breeding programme so far

Since the initial establishment and conversion of the rescue and diagnosis centre at Pinjore, Haryana, to a conservation breeding centre in 2004, there has been a series of centres established following a similar model in India: Rajabhatkhawa at Buxa Tiger Reserve, West Bengal, and Rani Forest, Assam (2005 and 2007 respectively). These were all established by Bombay Natural History Society, and the state governments of Haryana, West Bengal, and Assam respectively, largely with support from Darwin Initiative of the British Government, and the Royal Society for the Protection of Birds (RSPB). Meanwhile a centre was established at Changa Manga Forest in Punjab Province (established 2007), Pakistan by WWF-Pakistan and the Provincial Government of Punjab, and with a grant from the Abu Dhabi Environment Agency. The Central Zoo Authority has also supported five Indian zoos to develop vulture breeding facilities at or in close proximity to zoos in Gujarat, Andhra Pradesh, Madhya Pradesh, Orissa, and Jharkhand. These are at various stages of development and it is envisaged that they will become fully integrated with the overall programme. There are established governing bodies for each of the BNHS centres chaired by the state government Secretary of Forest Departments. Drawing upon experience from other parts of the world and comparable programmes, including raptor breeding expertise of UK's International Centre for Birds of Prey, California Condor work of the Peregrine Fund, and Eurasian Griffon Vulture successes in France and Spain is a crucial element that has already helped reach this point.

Major progress in the husbandry, including the use of large colony aviaries, and more recently, artificial incubation techniques and expertise have dramatically increased breeding productivity for these species each year. This is encouraging, especially considering they had not previously bred in captivity. The latest successes include definite cases of the incubation techniques inducing pairs to produce two successful fledglings in one season, hence hugely improving the potential capacity for the programme. The total numbers of birds (Table 1) is 271 in India, 60 in Nepal and 20 in Pakistan. The Indian CZA centres hold birds in addition to these.

Factors affecting captive population growth and probable release dates

With current progress and maturation of the birds held in the centres, there are several factors that will have major impacts on how quickly a surplus of birds will be available for release. A key factor is the starting number of birds, but other important factors are the age of first breeding (generally around 5 years), the proportion of paired-up birds, the sex ratio within any holding, and the survival rates of eggs laid. The survival of chicks to fledging has been improved by artificial incubation and hand-rearing, although birds of all three species have successfully fledged young within the aviaries. The potential for prompting double-clutching by early 'pulling' of the first egg, causing the birds to lay and rear a second egg and chick, has a massive impact and potential for speeding up the productivity. This artificial incubation option has been showing very promising signs of success since trials started in 2008. Among the anticipated variables that can influence the period until sufficient birds are available for release, whilst maintaining adequate future breeding stock. These positive signs mean that at the current rate we could have sufficient birds available as soon as 2016. Another important factor is the numbers of birds required for initial releases, and judging from work on the Eurasian Griffon Vulture, it is expected that a minimum of ten birds would be

Table 1: Numbers of each of the Critically Endangered *Gyps* species held in the SAVE Conservation Breeding Centres

Centre\ Species	Pinjore, Haryana, India	Rajabhatkhawa, W. Bengal, India	Rani Forest, Assam, India	Chitwan, Nepal	Changa Manga, Pakistan	Total
White-backed	62 (15)	52 (5)	27	60	20	221 (20)
Long-billed	66 (11)	17				83 (11)
Slender-billed	18 (4)	14 (1)	15			47 (5)
Total	146	83	42	60	20	351 (36)

(values in parentheses indicate numbers successfully fledged on site by November 2011) required, and that additional releases of similar numbers of birds would have to be carried out at a given release site in the subsequent two years. Careful monitoring of the initial releases will be needed and there will be some differences between the three species, and from these the methodology and exact timing will be refined for subsequent cases.

Future plans and Summary

Breeding techniques have now been shown to be available for captive populations of all three *Gyps* species, and with growing experience, there is every prospect that productivity of these will continue to improve. With this success comes a growing need for careful genetic management of the captive stock and further stepping up of productivity, so that sufficient birds are available for the pre-release phases once there are sufficiently large areas of established diclofenac-free environment. These areas are currently in the process of being established through intensive awareness and advocacy work in 100 km radius areas termed Provisional Vulture Safe Zones. Meanwhile, we face the serious challenge of coordinating, resourcing, and running the breeding centres, and getting the required expertise and experience fully available across the programme.

Experience is already being shared between the centres in the three countries holding captive birds, and joint training sessions increasingly involve staff from multiple centres. Although the prospects for the exchange of birds across the national boundaries involved may be a major challenge, exchanges of birds between centres within India should ameliorate the management problems and improve the prospects of success, and this is an area for our attention in future. The consortium of partners under the banner of Saving Asia's Vultures from Extinction ('SAVE' www.save-vultures.org) is collectively responsible for the majority of vultures held in captivity, and coordinates these efforts, but is aiming to help provide support for all centres sharing the objective to release birds and generate self-sustaining wild populations.

Genetic management, full coordination between centres, the successful removal of diclofenac from the environment through tighter legislation, and the establishment of 'Vulture Safe Zones', as well as a system of legally-binding mandatory vulture safety-testing for all cattle painkillers entering the market, are all further challenges that need to be overcome before the ultimate objective of releasing the birds back into the wild can be undertaken, and the conservation objectives for the three Critically Endangered *Gyps* vultures will be fully achieved. The breeding programme is, however, a key element of these efforts, and an essential step to securing the future of these species.

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STROPHOCINCLA LAUGHINGTHRUSHES OF SOUTH INDIA: A CASE FOR ALLOPATRIC SPECIATION AND IMPACT ON THEIR CONSERVATION

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The Western Ghats of southern India are home to four endemic laughingthrush taxa belonging to genus *Strophocincla*, currently lumped as two species, namely Black-chinned Laughingthrush *Strophocincla cachinnans* and Kerala Laughingthrush *Strophocincla fairbanki* – each of them with two races, namely *jerdoni* and *cachinnans* for the Black-chinned, and *fairbanki* and *meridionale* for the Kerala Laughingthrush. All of them inhabit montane ecosystems exclusively above *c.* 1,200 m and have been of great interest for speciation studies as they are strictly allopatric as their ranges are separated by valleys with unsuitable altitudes. This paper describes the morphological and geographical differences between these four races and proposes a case for considering each of them as an independent species based on the 'quantitative criteria for species delimitation' method. Based on this methodology, the forms *jerdoni* and *meridionale* were found to differ from *cachinnans* and *fairbanki* respectively, by scores sufficient to be ascribed a full species status. In the wake of this status change, the IUCN Red List criteria were applied to all four taxa and *S. jerdoni* was evaluated as Critically Endangered and *S. meridionale* as Endangered. This new found threat level is expected to catch the attention of forest departments and policy makers to advocate specific conservation actions to arrest the decline.

Key words: Laughingthrush, speciation, IUCN Red List, Western Ghats

INTRODUCTION

The Western Ghats of southern India are home to four endemic laughingthrush species belonging to genus *Strophocincla*, currently lumped as two species, namely Black-chinned Laughingthrush *S. cachinnans* and Kerala Laughingthrush *S. fairbanki* – each of them with two races namely *jerdoni* and *cachinnans* for the Black-chinned, and *fairbanki* and *meridionale* for the Kerala Laughingthrush (del Hoyo *et al.* 2007; Rasmussen and Anderton 2005). All of them inhabit montane ecosystems above *c.* 1,200 m and have been of great interest for speciation studies as they are strictly allopatric, their ranges being separated by valleys with unsuitable altitudes. The only other laughingthrush found in southern India is the monotypic Wayanad Laughingthrush *Dryonastes delesserti*, which is unrelated to the *Strophocincla* Laughingthrushes and inhabits low and mid-altitude forests of the Western Ghats (Sashikumar *et al.* 2011).

Taxonomic History – Splits and Lumps

FAUNA OF BRITISH INDIA (Oates and Blanford 1889), henceforth referred to as the OLD FAUNA, the first comprehensive treatise on Indian birds, included all the four forms of Laughingthrushes as individual species under the genus *Trochalopteron*. *T. cachinnans* was described from the Nilgiris as *Crateropus cachinnans* (Jerdon 1839) and it was later placed under *Garrulax* and then *Pterocyclus* before it settled under *Trochalopteron* in the OLD FAUNA. *T. jerdoni* collected from the Banasore (=Banasura) peak was described as *G. jerdoni* (Blyth 1851) but moved later to *Trochalopteron* in the OLD FAUNA. *T. fairbanki* was described from Palani Hills (Blanford 1869) and *T. meridionale* from south Travancore (Blanford 1880). Apart from these four forms, the OLD FAUNA also described a fifth from South India, *T. cinnamomeum*, from an unknown type locality (Davison 1886). This race has not been traced since then and recent ornithological works do not recognise this form (Rasmussen and Anderton 2005).

Baker (1927), henceforth referred to as the NEW FAUNA, adopted all five forms described in the OLD FAUNA – but did a small but important lumping. Baker (1927) treated *T. fairbanki* and *T. meridionale* as subspecies of *T. jerdoni* based on the 'grey breast' all three share. *T. cinnamomeum* was treated as a subspecies of *T. cachinnans* based on its rufous breast. This classification stood for nearly 80 years – except that all the forms were moved under *Garrulax* (Ali and Ripley 1987), which most field guides since then followed (Grimmett *et al.* 1999; Kazmierczak 2000). Rasmussen and Anderton (2005) finally revoked this lumping. They made a logical, though partial, move of lumping *G. j. jerdoni* with *G. cachinnans*, as they are endemic to the Ghats north of Palakkad (=Palghat) gap, an ancient divide responsible for speciation in the Western Ghats (Ali 1969). This also means that the *fairbanki* form returns to its species status with *meridionale* as its subspecies, both forms restricted strictly south of the Palakkad gap. They also reinstated the old genus name of *Trochalopteron* instead of *Garrulax* though the genus was changed again recently to *Strophocincla* (del Hoyo *et al.* 2007). We base our work on this taxonomy and discuss the validity of all the subspecies.

Distribution

All four *Strophocincla* Laughingthrushes are allopatric (Fig. 1). Form *jerdoni* is found in the hills of Coorg and Wayanad while *cachinnans* is mostly concentrated around Nilgiris with a vestigial population in Muthikulam hills lying immediately north of the Palakkad gap. Form *fairbanki* occurs in Nelliampathy hills immediately south of the Palakkad gap, mostly along Munnar-Kodaikanal hills and further south in High Wavies-Pandalam Hills until Shengottah (=Achenkovil) gap. Area south of Shengottah gap, known as Agasthyamalai hills, is the home of the *meridionale* form (Sashikumar *et al.* 2011). Details of the distribution are summarised in Table 1.

Objective

This paper describes the morphological and geographical differences between these four races and proposes a case for assigning species status based on 'quantitative criteria for species delimitation', a method described by Tobias *et al.* 2010. If this be the case, the current threatened status of these birds would also require re-evaluation and the same is also discussed.

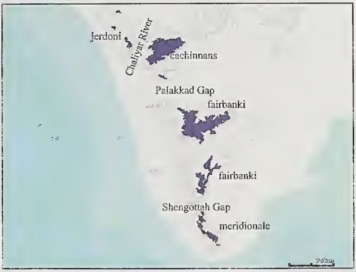

Fig. 1: *Strophocincla* distribution map

METHODOLOGY

Biological Species Concept (BSC) is still the most widely followed yardstick for designating bird species (Haffer 2007). However, evaluation of allopatric species inhabiting islands or continental islands is still a 'grey area' and mostly based on inference, on the degree of difference between two related sympatric species (Haffer 2007). Speciation rules of British Ornithological Union (BOU) are also framed using this concept "the level of divergence is equivalent to that found in related sympatric species" (Helbig *et al.* 2002). The concept of a 'species' may not be important to understand evolution or speciation (Tobias *et al.* 2010). However, this is a unit treated by conservationists and policy makers for formulating national and international law, and hence a consistent and transparent process should be followed in evaluating the same.

Table 1: Distribution of *Strophocincla* laughingthrushes of southern India

	S. jerdoni	*S. cachinnans*	*S. fairbanki*	*S. meridionale*
Range	Coorg & Wayanad Hills	Nilgiri & Muthikulam Hills	Anamalais, High Wavies & Pandalam Hills	Agasthyamalai Hills
Southern Limit	Chaliyar Valley	Palakkad Gap	Achenkovil Gap	None
Extent of Occurence	<100 sq. km	<1,500 sq. km	<2,000 sq. km	<300 sq. km
Area of Occupancy	Unknown	<250 sq. km	Unknown	Unknown
No of locations	3	3	7	5
Protected Areas (PAs)	Brahmagiri WLS, Aralam WLS	Mukurthi NP, Silent Valley NP	Indira Gandhi WLS, Chinnar WLS, Eravikulam NP, Anamudi Shola NP, Pampadum Shola NP, Mathikettan Shola NP, Kurinjimala WLS, Periyar TR	Shendurney WLS, Peppara WLS, Neyyar WLS, Kalakad-Mundanthurai TR, Kanyakumari WLS
Largest Population	Vellarimala-Chembra, Wayanad district	Nilgiris	Grass Hills-Eravikulam	Kalakad-Mundanthurai TR, Tirunelveli district
Extent of Occurence under PA Network	<15 sq. km	<100 sq. km	<200 sq. km	<275 sq. km
Current Status	EN	EN	NT	NT
States	Kerala, Karnataka	Kerala, Tamil Nadu	Kerala, Tamil Nadu	Kerala, Tamil Nadu

With this in mind, Tobias *et al.* (2010) framed a process based on a scoring system, and showed that their system performed with a high degree of consistency in evaluating known, well-accepted species and races. For a detailed description of the method the reader is directed to the original work; however, some clauses and assumptions made in that work are re-emphasised here.

Tobias *et al.* (2010) list a process which provides integral scores to the consistent differentiating bionomical, morphological, and acoustical features between two taxa. It is important to recognise that their method does not require molecular level differences though it is indicated as future work. To ensure that one single trait does not overwhelm the evaluation, at most two acoustical characters or two bionomical characters or three morphological characters can be considered in scoring. A total score of 7 or above is considered to be good for a species and statistically this number holds good for a large number of recognised species and subspecies. This method was also followed to evaluate Asian babblers (Collar 2006) and the recommendations made in that paper have been well accepted by the international community (Rasmussen and Anderton 2005). Of specific interest is the evaluation of allopatric races of two laughingthrush super-species from South Asia (Collar 2006) using this method. Bhutan Laughingthrush *S. imbricatum* was split from Streaked Laughingthrush *S. lineatum* and are allopatric despite close geographical approach. Similarly, the two south Asian taxa which were part of Chestnut-crowned Laughingthrush complex – Red-headed Laughingthrush *T. erythrocephalum* and Assam Laughingthrush *T. chrysopterum* – were split from each other (Rasmussen and Anderton 2005) while the extralimital Southeast Asian groups were split as Malayan Laughingthrush *T. peninsulae*, Golden-winged Laughingthrush *T. ngoclinhensis* and Silver-eared Laughingthrush *T. melanostigma* (Collar 2006). All five new species recognised thus are allopatric.

In this paper, we work with morphological characters (an upper limit of only three characters), which are described in well-known literature and hence there is no original data to be reviewed or vetted before this scoring can be used. In this new light, all the four taxa are re-evaluated using the IUCN Red List Categories and Criteria (IUCN Standards and Petitions Subcommittee, 2010) based on the thresholds of Extent of Occurrence (EOO) and Area of Occupancy (AOO) (Table 2), and their revised threat level established. This process banks heavily on data collected from the field through focused bird surveys undertaken by the authors and their associates in different parts of Western Ghats (Praveen and Nameer 2009). Based on these surveys, the EOO, defined as the shortest boundary drawn to encompass all the known, inferred, and projected sites of occurrence, excluding large areas of unsuitable habitats, and the AOO, defined as the area within its EOO which is occupied by the taxon, are calculated.

Table 2: IUCN thresholds for EOO and AOO

Category	EOO Threshold	AOO Threshold
Critically Endangered	100 sq. km	10 sq. km
Endangered	5,000 sq. km	500 sq. km
Vulnerable	20,000 sq. km	2,000 sq. km

RESULTS AND DISCUSSION

Table 3 describes the scoring for *S. jerdoni* (Fig. 2) with respect to *S. cachinnans* (Fig. 3), and Table 4 for *S. meridionale* (Fig. 5) with respect to *S. fairbanki* (Fig. 4). As can be seen from the result – both scores are good enough to be considered as full species purely based on morphological differences. Remarks column indicate the rationale for the scores and these are based on the guidelines of Tobias *et al.* (2010).

Speciation rules of BOU or Helbig *et al.* (2002), which compare the divergence against similar sympatric species, are less suited for our study as all the *Strophocincla* laughingthrushes in the world are allopatric. Sympatric laughingthrushes from other genera are fairly distinct in plumage and size, and do not appear to be good candidates for this level of comparison. Hence, the method we used is probably the only way to evaluate these four taxa within the purview of BSC.

However, the pre-application of this theory to the two laughingthrush groups by Collar (2006) enables us to compare our scores with these accepted species. It is important to note that the 'upper limit rule' of at most three morphological characters has not been followed in Collar (2006), and hence the published scores are higher than they should have been if based on the final species delimitation rules.

Without vocalisations, which are pending further study (Rasmussen and Anderton 2005), Bhutan Laughingthrush

Table 3: Scoring for *S. jerdoni* vs. *S. cachinnans*

Differences	Score	Remarks
Pale grey upper breast vs. Orange-rufous upper breast	4	Radically different colour to a significant plumage area
Grey ear coverts vs. Pale rufous ear-coverts	3	Entirely different colour to a part of the head
Sum of top 3 scores	7	

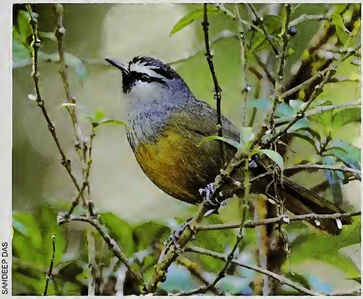
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Fig. 2: Banasura Laughingthrush *S. jerdoni*

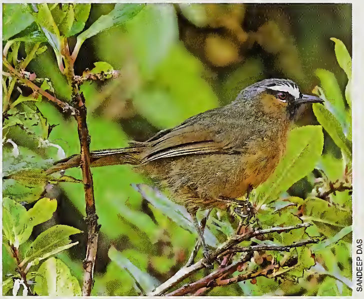
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Fig. 3: Nilgiri Laughingthrush *S. cachinnans*

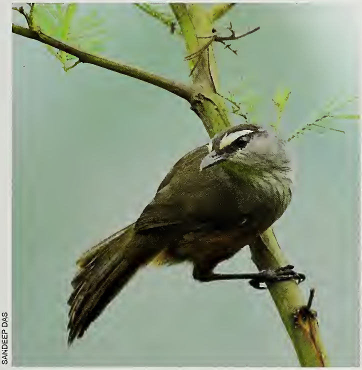
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Fig. 4: Palani Laughingthrush *S. fairbanki*

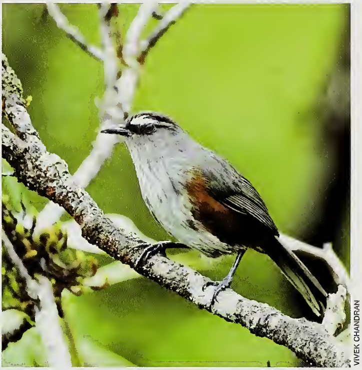
VIVEK CHANDRAN

Fig. 5: Travancore Laughingthrush *S. meridionale*

would score 6 on morphology with an additional single on biometrics, which makes it a full species with score 7. However, there are no striking differences (like rufous vs. grey) in its morphological differences with Streaked Laughingthrushes and still it qualifies as a full species.

The situation of Chestnut-crowned Laughingthrush is more interesting. On applying the 'upper-limit rule', the Malayan Laughingthrush would only score 5 (suggested 9 without upper-limit rule) on morphology, and their vocal and mensural differences are unknown. Gold-headed Laughingthrush would just scrape through with a 7 (in fact 6-7, suggested 7-8) while Silver-eared Laughingthrush would only score 4 on morphology with a perceived significant difference (score of 3) in its vocalisation of this taxa with that of *woodi* race of Red-headed Laughingthrush, which is the nearest geographical cousin. In every respect, the differentiation of *S. jerdoni* and *S. meridionale* forms is much stronger than these accepted species.

In this context, it may be worthwhile to mention the other two traits. Mensural traits of each of the races are given in the classical references. However, they cannot be used for this analysis as the raw data is not available for calculating the variance. Min-max values were overlapping and the nominate forms seem to have a greater min-max variation.

This could be attributed to the lack of sufficient sample size for the other two 'rarer' races. None of the available literature mentions an observable difference of size in any of the body parts. Hence, if indeed there is a mensural difference, the scores might not be sufficiently high to aid a positive delimitation.

Similarly, there are no prior studies on the acoustical differences between the taxa. At the time of writing, preliminary surveys to document the calls are underway and should hopefully provide more insights into any differentiation at this level. Tobias *et al.* (2010) observed that there is a strong negative correlation between the scores of morphological traits and acoustical traits – hence, it would not be surprising if the experiment determines that there is no statistically significant acoustic differentiation.

The last frontier for speciation studies is at the molecular level. This would provide an insight on how genetically divergent each of the populations is. Similar works in other species (Robin *et al.* 2010) have found out that ancient gaps in hill ranges have shaped speciation in the birds of the Western Ghats. Hence, this hypothesis should also be tested with molecular samples to determine the genetic divergence of these taxa.

Naming

It is probably inappropriate to suggest new names for the four taxa studied here and it is strongly felt that the original names proposed by the 19th century ornithologists should be reinstated (see Table 5).

Conservation

As the motive for reassessing these species limits has been for conservation, it is worth revising the threatened status of all the four races against IUCN criteria according to their current status (Table 1).

The available information for all four species is similar. EOO for all four species is well-defined while information on AOO is meagre with the possible exception of Nilgiri Laughingthrush (Zarri *et al.* 2008). There is a wealth of data on the range fragmentation and sub-populations. Risks like habitat loss, loss of habitat quality and habitat transformation are present for all the species in varying degrees. Areas that fall within PA network are also known, which helps to estimate the likelihood of assessed risks. Based on this information, the following is proposed for each species.

Banasura Laughingthrush: The species (Fig. 2) has a small geographical range characterised by an EOO less than 100 sq. km threshold (actual < 57 sq. km), which in itself is severely fragmented and continues to decline due to loss of habitat and the same is feared to have gone locally extinct in a few locations. Hence, it qualifies as Critically Endangered under B1abiv (IUCN 2011). The supporting data is as follows:

1. Recent surveys (post 2005) have recorded this species only in Vellarimala, Chembra, and Banasura, all in Wayanad district of Kerala and Ambalapara-Brahmagiris along the Karnataka-Kerala border. With the exception of Brahmagiris, the bird has been partial to altitudes above 1,600 msl.

2. Past reports during expeditions by other birdwatchers include sightings from Pushpagiri Wildlife Sanctuary (WLS) (1997), Kudremukh National Park (NP) (2001), Bababudan Hills (2002), all in Karnataka and Kurichyarmala (1998) in Kerala, all sites having a likely altitude and similar habitat to support this species. However, the bird has not been recorded from these sites post-2005, despite surveys with specific focus on high altitude endemics – indicating a continuing decline in the number of locations. It should be noted that even if we include the habitats in all these sites, the EOO is just 90 sq. km, sufficiently below the CR threshold.

3. Vellarimala (29.39 sq. km) and Chembra (7.46 sq. km) regions are likely to be connected populations as both are part of a high plateau (1,400 msl), while Banasura (4.63 sq. km) and Brahmagiris (14.83 sq. km) are disjunct. Hence, the population is severely fragmented into three sub-populations with potentially the largest occurring in Vellarimala-Chembra. Except for Brahmagiris, all other regions fall outside the PA network.

Nilgiri Laughingthrush: This species (Fig. 3) has a small geographical range characterised by an EOO less than 5,000 sq. km threshold (actual <1,500 sq. km) and an AOO less than 500 sq. km threshold (actual <250 sq. km), and this range is severely fragmented and continues to decline due to

Table 4: Scoring for *S. meridionale* vs. *S. fairbanki*

Character	Score	Remarks
Prominent dark streaks on breast vs. Very weak stripes on breast	3	Entirely different pattern
White centre of belly vs. Solid rufous-chestnut belly	3	Entirely different colour to a part of the body
Greyer upperparts vs. Medium brown upperparts	2	Different tone
Shorter white supercilium vs. Long white supercilium	1	Distinctly different pattern
Pale brown crown vs. Dark brown crown	1	Slightly different wash
Sum of top 3 scores	8	

loss of habitat quality. Hence, it qualifies as Endangered under criteria B1abiii and B2abiii (IUCN 2011). This species was already listed as Endangered prior to the taxonomic merger with *S. jerdoni*. The supporting data is as follows:

1. Based on studies in the Nilgiris (Zarri *et al.* 2008), AOO is estimated as 210 sq. km, and even if the EOO of Muthikulam population (25 sq. km) is included, it is well short of the AOO threshold for Endangered. The species occupies altitudes above 1,600 msl and possibly down till 1,400 msl for dispersal. Total area above 1,400 msl in its range (same as EOO) is below 1,500 sq. km: 1,454 sq. km in Nilgiris and 25 sq. km in Muthikulam.

2. Studies in the Nilgiris (Zarri *et al.* 2008) indicate that the population survives in small sholas, which are extremely fragmented, and suffers serious habitat loss due to conversion of sholas for other purposes like roads, buildings, plantations, etc.

Palani Laughingthrush: This species (Fig. 4) has a small geographical range characterised by an EOO less than 5,000 sq. km threshold (actual <2,000 sq. km) and occurs in not more than five locations. However, there is no observed, inferred, or projected evidence of continuing decline in any of the parameters. Since the species almost meets Endangered criteria B1ab, it may be treated as Near Threatened. This species was listed at the same level till date, irrespective of taxonomic revisions. Any information on continuing decline in the future may warrant uplisting.

Travancore Laughingthrush: This species (Fig. 5) has a small geographical range characterised by an EOO less than 5,000 sq. km threshold (actual <304 sq. km), which in itself is severely fragmented and continues to decline due to loss of habitat quality. Since AOO is a part of EOO which is 304 sq. km, AOO is also less than 500 sq. km. Hence, it qualifies as Endangered under criteria B1abiii and B2abiii (IUCN 2011). Supporting data is as follows:

1. Recent surveys have recorded it mainly from Kalakkad-Mundanthurai Tiger Reserve (KMTR) and adjoining Neyyar-Peppara WLS, apart from Pandimotta and Vairattimotta areas in Shendurney WLS and Mahendragiri in Kanyakumari WLS. In all regions, the species occurs clearly above 1,200 msl. Total EOO of this population is only 304 sq. km. and spread across the four locations, the largest being KMTR region (230 sq. km) and three smaller blocks like Vairattimotta (14.75 sq. km), Pandimotta (56.14 sq. km), and Mahendragiri (3.55 sq. km).

Table 5: Common Names for *Strophocincla* laughingthrushes

Common Name	Scientific Name
Banasura Laughingthrush	*Strophocincla jerdoni*
Nilgiri Laughingthrush	*Strophocincla cachinnans*
Palani Laughingthrush	*Strophocincla fairbanki*
Travancore Laughingthrush	*Strophocincla meridionale*

2. Recent studies have found that the density of breeding territories of this taxon is negatively correlated to the density of *Ochlandra* reeds in the territory. Montane forests in these hills have been replaced in several parts by brakes of *Ochlandra*, probably after clear felling and forest fires wiped out the natural vegetation. The transition in habitat is believed to be a recent phenomenon and there is a potential threat from forest fires (Vivek Chandran *in litt.*), and habitat quality is thus being affected.

Based on this new information, great emphasis should be given to the conservation of *S. jerdoni* and *S. meridionale* – both taxa which were subsumed under more widespread nominates, and hence had not received the attention of policy makers.

CONCLUSION

It is expected that the possibility of *S. jerdoni* and *S. meridionale* being raised to full biological species will bring additional attention from the concerned forest departments and montane areas of conservation significance will be demarcated as protected areas to control the continuing decline in these habitats. On the global scale, application of the scoring based species delimitation would enable reassessment of several similar allopatric biological species, which have not received conservation attention from policy makers.

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RECENT TRENDS IN MARINE BIRD MONITORING IN INDIA

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Studies on marine birds of India are scarce and available information is based mainly on wind-blown bird data and a few isolated off-shore trips. An attempt was made in recent years to address this lacuna by conducting off-shore trips from the coasts of Karnataka and Kerala to monitor marine birds. We report the significant results from these studies and demonstrate a simple and sustainable methodology for similar future surveys. The study indicates the presence of a good number of pelagic birds off the south-west coast of India belonging to ten species, including a few significant records for the two states. Comparison with prior wind-blown records suggests a negative correlation for a large number of species indicating that such off-shore surveys are the only way to document the status of pelagic birds in our waters. This study also indicates the presence of both boreal and austral breeders wintering and summering in our region respectively. We highlight the potential threats to marine birds in the Arabian Sea and emphasise the need for such future studies. We summarise the hurdles, improvements, and actions in executing such surveys, potentially involving collaboration of larger regional agencies involved in marine research.

Key words: pelagic birds, bird monitoring, Kerala, Karnataka, shearwaters, storm-petrels, jaegers, boobies

INTRODUCTION

The marine ecosystem in general is one of the less monitored ecosystems in the world – marine studies have largely been concentrated on fish-catch and understanding the oceanographic factors affecting fish resources. Though monitoring of marine birds is almost unheard of in India, detailed methodologies and the relevance of such studies have been documented elsewhere (Walsh *et al.* 1995). Due to this lack of monitoring, the data on Indian marine avifauna is also meagre (Robertson 1995), as apart from isolated boat trips, or expeditions to Lakshadweep (Mathew and Ambedkar 1964; Mohan 1989; Pande *et al.* 2007), this data has been compiled only from wind-blown records (Sashikumar *et al.* 2011). During recent years, regular sea-watching conducted from the Sri Lankan coast has provided interesting records and information (de Silva 1987, 1997). It was therefore felt necessary to conduct similar sea-watching surveys from the Indian coast to collect more information on our marine birds. In general, seabirds are more threatened than many other groups of birds and their status has deteriorated faster than others over the recent decades (Croxall 2012), hence, it is important to study and monitor the status of marine avifauna of the region. Kerala is well-known for co-ordinated bird-surveys to monitor threatened birds of Western Ghats (Praveen and Nameer 2009). So, in the last two years, an attempt was made to harness the same human resources to monitor seabirds as well. As a part of this exercise, a set of ten expeditions (totalling 19 field days, i.e. more than 120 hours) were conducted in the Arabian Sea from seven different points on the south-west coast from 2010-2012 (between Udupi in Karnataka and Kochi in Kerala) and the results have been encouraging. This paper summarises the preliminary findings from these surveys (Chandran *et al.* 2011; Praveen *et al.* 2011; Shivashankar *et al.* 2011) and proposes a simple, tested field methodology for comparative studies.

METHODOLOGY

The objective was to conduct a survey in every season of the year to understand the pattern of seabird abundance. Hence, trips were conducted in all months of the year except June, August, November, and December, covering winter, pre-monsoon, monsoon, and post-monsoon seasons. The trips were mostly made in fishing boats. Observations were made using binoculars and photographs were taken to help in species identification. All seabirds sighted within an estimated 200 m on either side of the boat were identified to the lowest taxonomic level possible using standard field guides (Harrison 1985, 1996; Rasmussen and Anderton 2005). The surveys were conducted from Malpe (Udupi) (13°20'52" N; 74°42'1" E), Mulki (13°4'46" N; 74°46'25" E) and Mangalore (12°51' 30" N; 74°49'56" E) in Karnataka and Azheekkal (Kannur) (11°91'20" N; 75°31'95" E), Chombala (11°56'54" N; 75°59' 14" E), Chettuva (10°30'31" N; 76°2'10" E), and Munambam (Kochi) (10°11'2" N; 76°10'25" E) in Kerala (Fig. 1).

The varying abundance patterns of migrant sea-birds in our seas, lack of obvious nesting colonies on the south-west coast of India, nature of the craft available for surveys and the expertise level among birdwatchers in monitoring

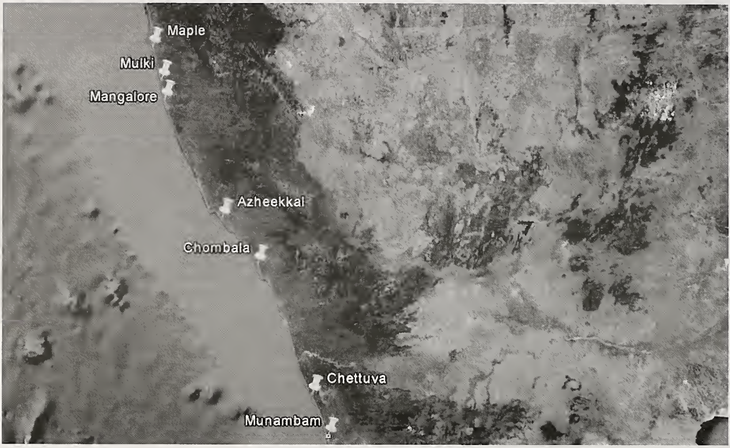

Fig. 1: Map of locations of the pelagic surveys

sea-birds influence the design of a feasible and sustainable methodology for monitoring marine birds. During the initial phases of the survey, a simple method requiring minimal effort was used to collect data. Later, a slightly more rigorous methodology was evolved for data collection and analysis.

Pilot Survey Methodology

Some of the seabirds preferred to follow fishing boats whereas others did not. In order to sample birds with both preferences, surveys were planned for two days whenever possible – one day was spent following fishing boats (generally up to 20 km from the shore) and moving parallel to the shore, and the next day was used to go to deeper sea (up to 45 km from the shore). *Chum* (bait) was not used in these surveys. The time, species, and number of birds were noted for each sighting. Using prior knowledge (Ali and Ripley 1987; Sashikumar *et al.* 2011), the index of relative abundance from pilot surveys was compared with the wind-blown records in a scatter-plot to identify if they were correlated.

Intensive Survey Methodology

The intensive surveys during this study were a modification of the methodology used by Bailey (1968). The last four surveys were done using this methodology, which was found adequate for basic analysis of abundance and distribution, and was feasible and easy to execute. The method helps to identify the preferential distance-bands of different species and compare them across sites and across species.

The area surveyed was logically split into multiple distance bands based on the distance from the coast (0-10 km, 10-20 km, etc.) – bands were determined using GPS. Similarly, the survey time was logically split into multiple time bands (with 30 minute intervals, aligned to hour boundaries).

The data recorded is given below:

- GPS location was collected at a constant interval of 10 minutes from the time when the boat enters the sea till the boat was either anchored (in case of overnight stay) or when it starts its return journey. This can be done with the help of a GPS device or even with a GPS equipped smart phone.
- When birds are sighted, the time, species and count are recorded.

The above data helps to determine:

- Location of sighting (extrapolated from adjacent GPS positions).
- Species-wise distribution across distance and time bands.

- Abundance of various species across distance and time bands.

RESULTS

Ten species of seabirds belonging to five families were recorded during ten expeditions conducted from the west coast of India during 2010-12.

Significant Bird Sightings

Jouanin's Petrel ***Bulweria fallax***: About 10 sightings from the coast of Kannur on September 24, 2011. This is the second record from Kerala coast (Sashikumar *et al.* 2011) and probably the tenth within Indian waters (Robertson 1995). The species is considered Near Threatened by IUCN due its restricted distribution and tiny breeding range.

Flesh-footed Shearwater ***Puffinus carneipes***: One of the commonest seabirds during May-October with huge congregations, sometimes up to 500 (Chandran *et al.* 2011), were recorded near fishing fleets. Prior to this study, there is only a single record of this species from Kerala (Praveen *et al.* 2011; Sashikumar *et al.* 2011).

Wedge-tailed Shearwater ***Puffinus pacificus***: A single bird photographed from the coast of Kannur on May 28, 2011; this was the first record for Kerala (Praveen *et al.* 2011).

Persian Shearwater ***Puffinus persicus***: Recorded from Kerala (Praveen *et al.* 2011) and Karnataka coast (Shivashankar *et al.* 2011) during March-April with a maximum flock size of 23 birds on April 05, 2011, from Kannur coast, prior to this study – there has been only one record from Kerala and another from Karnataka.

Wilson's Storm-Petrel ***Oceanites oceanicus***: Studies indicate that this species is present in our seas between May-October and is reasonably common from about 40 km off-shore. Prior to these studies, there have been no sightings of this species from Karnataka and just two reports from the coast of Kerala (Chandran *et al.* 2011; Praveen *et al.* 2011).

Swinhoe's Storm-Petrel ***Oceanodroma monorhis***: Recorded from the Indian coast for the first time in July 2011 (Chandran *et al.* 2011). The bird was found to be reasonably common in subsequent surveys in September and October from the Kerala and Karnataka coasts respectively – and was an addition to the bird checklist of both states.

Parasitic Jaeger ***Stercorarius parasiticus***: The most common jaeger species recorded during the surveys, most sightings were during September-April. Prior to this study, the species was considered a vagrant to the west coast (Rasmussen and Anderton 2005) with single records from Kerala and Karnataka.

Pomarine Jaeger ***Stercorarius pomarinus***: Rasmussen and Anderton (2005) report it to be more common than *S. parasiticus* on the west coast. We, however, recorded it only on March 04, 2012, from the Mangalore coast; this is the first record from the Karnataka coast.

Pilot Survey Results (September 2010 to July 2011)

Based on the species-wise bird counts, abundance of the birds was calculated as average number of birds recorded per hour (Table 1). Bridled Tern *Onychoprion anaethetus*, Flesh-footed Shearwater and Wilson's Storm-Petrel accounted for the maximum number of identified birds.

Comparison of wind-blown species records from the south-west coast of India vis-à-vis the records from the recent pelagic expeditions were plotted on a scatter plot as index of abundance on each axis (Fig. 2). Contrary to our expectations, the abundance level of each species at sea is different from its abundance level in the wind-blown records – and many species show an inverse relation. If the rate of recovery of wind-blown

Table 1: Abundance data for Pilot Surveys of 2010-2011 (in decreasing order of abundance)

Species	No of Birds/Hour											
	Sept.	Sept.	Jan.	Jan.	Jan.	Apr.	Apr.	Apr.	Apr.	May	May	Jul.
Flesh-footed Shearwater	62.50	11.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78	4.71	125.00
Bridled Tern	0.50	11.11	0.00	0.00	0.00	5.26	1.25	28.57	72.22	14.81	8.24	5.00
Wilson's Storm-Petrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	12.50
Sooty Tern	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.59	8.24	1.88
Persian Shearwater	0.00	0.00	0.00	0.00	0.00	0.32	0.00	3.81	4.44	0.00	0.00	0.00
Parasitic Jaeger	1.88	1.11	0.67	0.33	0.00	0.11	0.38	1.90	1.78	0.00	0.12	0.13
Masked Booby	0.25	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wedge-tailed Shearwater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00
Swinhoe's Storm-Petrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13

species and what is seen from the boat are similar, we would have expected more entries in the first quadrant (close to 0). For example, the most common birds according to our surveys were Bridled Tern and Flesh-footed Shearwater, and there are very few wind-blown specimens of both (Fig. 2).

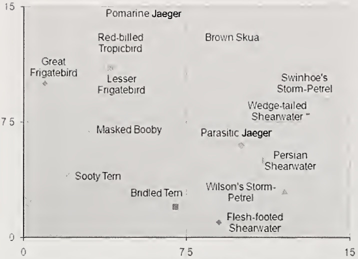

Fig. 2: Scatter plot showing abundance of wind-blown species (X-axis) vs. abundance of species seen from boat (Y-axis)

Intensive Survey Results (September 2011 till date)

Based on the total number of birds sighted across the four trips and the total number of hours spent in the field, the abundances of various species observed during different time-bands were plotted as the percentage of time-bands when the bird was observed (Table 2). Since, this is an ongoing study, here we only indicate how this method can be used to compare the results and carefully be generalised by indicating a few special cases.

Case 1: Comparison of relative abundance of Bridled and Sooty Terns (Kannur, September, 2011)

In general, Bridled Terns were much more common than Sooty Terns *Onychoprion fuscatus* at sea – contrary to what the wind-blown records indicate. Comparison of the abundance indicator of both the terns is shown in Fig. 3. Sooty Terns prefer areas further from the coast (about 40 km offshore), while Bridled Terns are found across the entire range from the sea coast till about 90 km.

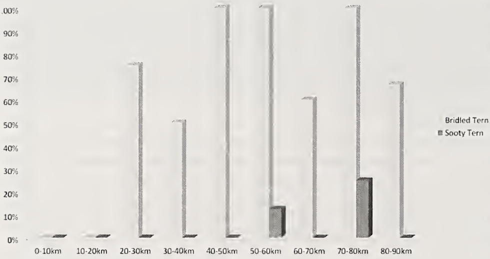

Fig. 3: Comparison of abundance of Bridled and Sooty Terns at Kannur

Case 2: Comparison of relative abundance of Bridled Tern, Wilson's Storm-Petrel and Parasitic Jaeger from Kannur (September 2011) and Udupi (October 2011)

Table 2: Combined abundance data from intensive surveys as % time bands where the species was present

	Distance bands (in km) and values expressed as % of total number of time bands								
Species	0-10	10-20	20-30	30-40	40-50	50-60	60-70	80-90	90-100
Bridled Tern	9.09	50.00	71.43	69.23	78.95	75.00	50.00	100.00	66.67
Sooty Tern	0.00	0.00	0.00	0.00	0.00	6.25	0.00	25.00	0.00
Flesh-footed Shearwater	0.00	0.00	0.00	0.00	5.26	12.50	16.67	25.00	33.33
Persian Shearwater	0.00	0.00	0.00	0.00	5.26	0.00	0.00	0.00	0.00
Jouanin's Petrel	0.00	0.00	0.00	0.00	0.00	6.25	0.00	0.00	100.00
Wilson's Storm-Petrel	0.00	0.00	14.29	0.00	10.53	43.75	100.00	100.00	100.00
Swinhoe's Storm-Petrel	9.09	18.75	21.43	23.08	10.53	25.00	66.67	100.00	66.67
Masked Booby	0.00	6.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parasitic Jaeger	0.00	43.75	28.57	7.69	47.37	12.50	0.00	25.00	0.00
Pomarine Jaeger	0.00	0.00	0.00	0.00	31.58	0.00	0.00	0.00	0.00

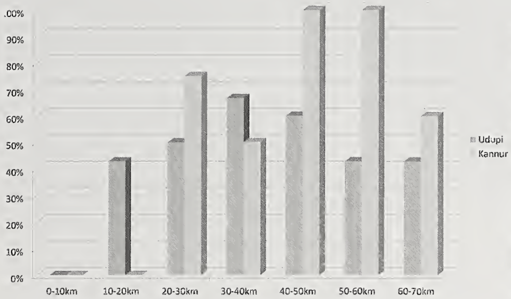

Fig. 4: Comparison of abundance of Bridled Tern between Udupi and Kannur

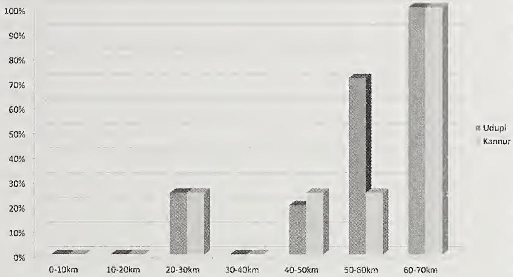

Fig. 5: Comparison of abundance of Wilson's Storm-Petrel between Udupi and Kannur

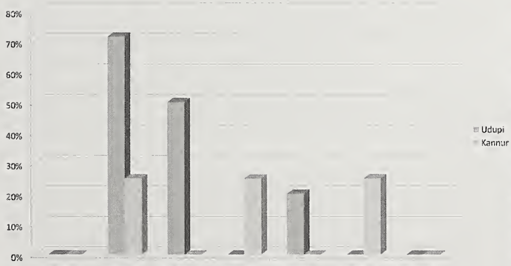

Fig. 6: Comparison of abundance of Parasitic Jaeger between Udupi and Kannur

In order to understand how the species are distributed across our coast, the occurrence data between the Kannur and Udupi trips was compared. Three sample species from different groups, which were relatively common in both the surveys, were taken for the comparison (Figs 4, 5, 6).

From the above comparisons, it is interesting to note that the distribution of Bridled Tern and Wilson's Storm Petrel are similar across Udupi and Kannur. On the other hand, the distribution of Parasitic Jaeger between the two places is not similar. This may be due to the fact that Parasitic Jaegers are large, nomadic, and kleptoparasitic, and hence may wander huge distances based on availability of food and concentration of other bird species on which they depend.

DISCUSSION

The present study revealed the presence of a good number of marine birds in the off-shore waters of the west coast. Many of the bird sightings were near the coast (within 20 km), indicating that the birds may not be difficult to find once one ventures further into the sea.

Trends in Distribution

Comparison of wind-blown records with offshore records (Fig. 2) clearly indicates the need for intensive pelagic exploration to understand the status of our seabirds.

Across the distance bands, at least two species showed strong affinity to the distance from the coast which is indirectly related to the depth of the sea bed. Wilson's Storm-Petrel was particularly numerous after a distance of 40 km from the coast in September and October. Jouanin's Petrel sightings during

September 2011 were at a distance of more than 80 km from the coast. The distance of the continental slope on the south-west Indian coast varies between 60 and 90 km – where the depth plunges from a mere 200 m to 1,000 m within a distance of 30 km. These regions have been traditionally associated with high productivity and frequent upwelling (Garcia *et al.* 2007; Ingole and Koslow 2005; Mossop 2007) – hence we should expect high density of seabirds in this region. Due to limitations of the boat, our surveys were not sufficiently geared to cover these distances.

Migration

The study also gave a fair understanding on the migratory patterns of our common pelagic birds – indicating the presence of breeding residents, boreal breeders that are winter visitors, austral breeders that are summer visitors, and passage migrants. Bridled Terns were present throughout the year and are probably residents from the breeding colonies known from Pittie Island in Lakshadweep (Pande *et al.* 2007) – prior to the survey, it was believed that the birds were mainly seen during autumn passage in SW India (Rasmussen and Anderton 2005). Sooty Terns are monsoon visitors to our seas occurring between May–September and this also concurs with the large number of wind-blown records during this period. Flesh-footed Shearwaters and Wilson's Storm-Petrels are summer visitors, peaking in numbers during the monsoon – in line with current knowledge that they spend only the austral summer in Indian Ocean. On the contrary, Persian Shearwaters are found only during spring passage (March–April) to the Persian Gulf where they breed (Rasmussen and Anderton 2005). Parasitic Jaeger and probably Pomarine Jaeger too are mainly winter visitors seen mostly between September-April and migrate north in summer. Movements of Swinhoe's Storm-Petrel are unclear at the moment – most records have been during autumn passage (September–October) with single birds seen during July and March.

Threats

The study is too short to assess any threats to the seabird species recorded. Elsewhere, longline fishing has been attributed as the cause of death of several seabirds (Brothers *et al.* 2010), the majority of them being Albatross (Family Diomedeidae). In March 2012, a Pomarine Jaeger was photographed with a longline fishing thread hanging from its beak – the bird probably gorged on the bait which got stuck in its throat. In April 2011, a Persian Shearwater was photographed with a fishing net entangled in its legs, and the bird struggling to fly. These observations indicate that our seabirds could also be facing the same threats documented elsewhere and a more careful monitoring on the fishing practices, by-catch and mortalities has to be conducted to design our fisheries to be less intrusive to the marine ecosystem.

Conservation and Marine IBAs

Bombay Natural History Society (BNHS) has started identifying important marine regions as Important Bird Areas (Kasambe 2011) and the current data indicate that there are several regions in the south-west coast of India that qualify as pelagic assemblages. However, most seabirds are not sedentary but free-ranging, hence it would be tough to identify a specific focus area to demarcate as an IBA.

CONCLUSIONS

This is the first study to examine seabird assemblages along a latitudinal gradient extending from Udupi in Karnataka to Kochi in Kerala along a distance of *c.* 400 km along the south-west coast of India. This study indicates that the calculation of distribution and abundance based on wind-blown specimens may not be completely accurate and bird surveys similar to the current study are necessary to get more accurate information. This study also indicates that the density of seabirds across months is not uniform, hence the necessity of studies covering the whole year. Ocean conditions are dynamic and change from year to year, particularly in the wake of climate change (Jennings and Brander 2010) and it is essential that we place our observation in a larger oceanographic context covering all the seasons. Thus, additional surveys are required to assess how the marine communities of the west coast of the Arabian Sea shift spatially and temporally. The study also demonstrates a simple proven methodology for seabird surveys, which can generate data for comparative studies in future.

The results of the present study indicate that regardless of the survey method employed, studies that use a band method, and that are designed to obtain accurate estimates of seabird abundance, require multiple observer teams using two or more observers on watch simultaneously with at least one person taking photographs for confirmation.

As the national research institutes like Fisheries Survey of India (FSI), National Institute of Oceanography (NIO), Central Marine Fish Research Institute (CMFRI) and Zoological Survey of India (ZSI) are already exploring the seas in various ways with their own vessels and facilities, collaborative pelagic expeditions with these institutes may reveal many interesting results on marine ornithology.

In addition to the practical difficulty of the availability and cost of boats, a major impediment to such studies is the lack of expertise among birders on marine birds. So it is also suggested that the birding networks covering the western coast should emphasis study of seabirds to build this expertise.

ACKNOWLEDGEMENTS

The pelagic surveys on the south-west coast have been largely a team exercise with more than fifty birdwatchers and photographers participating; these results are due to their earnest efforts at sea to document marine birdlife. We as authors are mere representatives of the larger team and our acknowledgement is due to all of them. However, some have played a greater role and we take this opportunity to thank and appreciate their efforts. Shivashankar M. of S.A. Hussain Memorial Trust conducted all the five surveys from the Karnataka coast. Dr. Dineshan Cheruvat organised the four surveys from Kannur, Sathyan Meppayur, P.P. Sreenivasan, and K.G. Dilip coordinated one leg each of these surveys, and C. Sashikumar organised two legs from Kannur, as part of the Malabar Ornithological Survey. Sudhir Naik analysed the data of the Udupi survey. Postmortem analysis of many of the pictures was done by Mike Prince.

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SONGS AND CALLS OF INDIAN BIRDS: IMPLICATIONS FOR BEHAVIOURAL STUDIES, SYSTEMATICS AND CONSERVATION

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This paper highlights the acoustical characteristics of the vocalizations of some Indian birds and their significance for behavioural, systematic, and conservation studies. The Indian birds investigated are known to use a varied range of species-specific vocalizations composed of simple, context-specific, monosyllabic, monotonous calls to highly varied, frequency modulated and complex songs. The frequency of most calls and songs ranged between 2 to 8 kHz. Non-passerine birds produced mostly simple vocalizations such as alarm, contact, flight, threat, territory and begging calls. Vocal repertoire of most passerines (songbirds) comprised songs and six to ten types of calls. Two categories of songs were mostly observed in bulbuls and robins. Type-A songs were discrete, composed of strophes or phrases preceded and followed by temporal intervals. These songs were simple, stereotyped, spontaneous, and common. Type-B songs were rare, female-oriented, and more complex. Song characteristics are highly diverse among Indian songbirds. The Common Tailorbird *Orthotomus sutorius* and Black-throated Prinia *Prinia atrogularis*, produced simple repetitive songs, while the Red-billed Leiothrix *Leiothrix lutea* and Verditer Flycatcher *Eumyias thalassinus* produced complex, frequency modulated songs. Females of bulbuls and mynas sang quite frequently, while it was rare in some species (e.g. Oriental Magpie-Robin *Copsychus saularis*).

Key words: Indian birds, songs, calls, vocal repertoire, bioacoustics, animal behaviour

INTRODUCTION

Vocalizations are an important means of communication in birds and play a significant role in breeding, mating, sexual selection, cognition, cohesiveness, and foraging, and are thus essential for survival. Over the decades, these have been extensively used in science to address questions pertaining to animal behaviour, ecology, evolution and neurobiology. Vocalizations have been used to infer relationships, both within and between genera, and have been crucial in the discovery of many new avian species (Alstrom and Ranft 2003). Birds produce a wide range of context-specific simple to complex signals, which can be named as songs and calls (Catchpole and Slater 1995). Generally, songs are long, complex vocalizations, and in birds serve two major functions, i.e., the establishment and maintenance of territory, and mate acquisition (Catchpole and Slater 1995). Song characteristics, such as phonetics (acoustical features), syntax (mode of production), temporal pattern and structural complexity (variability of elements) are highly diverse among oscine birds (Marler and Slabbekoorn 2004). In many species, repertoire is organised around a limited number of strophes or song types. In others, the song is composed of a large number of dissimilar structured song elements with an unrestricted number of combinations (Podos *et al.* 1992). The calls are often shorter, simpler, and monosyllabic, with simpler frequency patterns and produced by both sexes in various contexts. The calls play an important role in the sociobiology of birds, namely social contact, parent-offspring interactions, cohesiveness among flock/family members, threat and danger. The repertoire of signals varies from species to species, sometimes quite small and sometimes unmanageably large. Relatively few have been intensively studied, and the entire repertoire has not often been thoroughly documented (Marler and Slabbekoorn 2004). Though the importance of avian bioacoustic studies in behavioural ecology, sociobiology, evolutionary biology and neurobiology has been established globally and in India, yet scientific studies on their vocalizations are scanty (Kumar 2003). The present article highlights the general acoustical characteristics and biological significance of songs and calls of Indian birds, using some examples of Indian bird vocalization and available literature. Vocal repertoire of the Brahminy Starling *Temenuchus pagodarum* and song categories in White-eared Bulbul *Pycnonotus leucotis* have been carried out in detail.

METHODOLOGY

During April 1997 to June 2011, the songs and calls of over 200 species of birds were recorded at various locations, mostly in eastern and western Himalaya. Signals were recorded using Sony PCM-M1 or Marantz PMD222/PMD670 digital sound recorders and JVC MZ-500 or Sennheiser ME-66/Audio-Technica AT815b microphones and analysed using

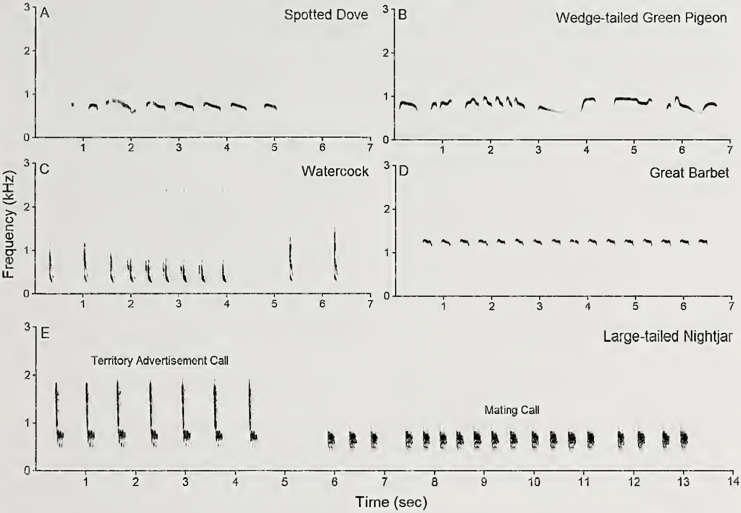

Fig. 1: Spectrograms of some vocalizations in non-passerine birds. (a) Territory advertisement calls of Spotted Dove, (b) Vocalizations of Wedge-tailed Green-Pigeon, (c) Territory advertisement calls of Spotted Dove, (d) Territory advertisement calls of Great Barbet, and (e) Two distinct categories of vocalizations in Large-tailed Nightjar

Avisoft SAS Lab Pro. Apart from recording the songs and calls in general, the vocal repertoire of some passerine species, Oriental Magpie-Robin *Copsychus saularis*, Indian Black Robin *Saxicoloides fulicatus*, Brahminy Starling *Temenuchus pagodarum*, Himalayan Bulbul *Pycnonotus leucogenys*, Red-vented Bulbul *Pycnonotus cafer*, and White-eared Bulbul *Pycnonotus leucotis*, were recorded in detail. Vocal repertoire of Brahminy Starling was documented based on the occasional recordings carried out on twelve individuals in northern India. Song categories in White-eared Bulbul were based on songs (N=8) recorded at Jodhpur during 2001. For bioacoustic analysis, spectrograms were displayed on a computer monitor and measurements of variables were made using frequency and time coursers. All spectrograms were calculated using following setting of SAS Lab: 512 FFT-length, 100% Frame, Flat Top window and 75 to 87.5% time window overlap. In some cases the temporal resolution was decreased or increased from 50% to 93.75%, as required. Software SPSS was used for statistical analysis.

RESULTS AND DISCUSSION

Bioacoustic analysis and interpretation of data reveals that most species used a varied range of context-specific vocalizations composed of simple, context-specific, monosyllabic, monotonous calls to highly varied, frequency modulated and complex songs. The frequency of most calls and songs ranged between 2 to 8 kHz.

Vocalizations of non-passerine birds: Non-passerine birds such as barbets, hornbills, kingfishers, cuckoos, owls, nightjars, doves, and pigeons were seen to produce mostly simple calls, often accompanied with visual displays for communication. Among these, male cuckoos, nightjars, and barbets used simple, loud, repetitive calls as a song resembling whistles, flutes or hiccups for territorial advertisement and sexual attraction. All species used signature vocalizations, e.g., cuckoos used their own species-specific songs composed of discrete repetitive phrases, further made up of mostly simple, frequency modulated elements usually low frequency ranging from 0.5 to 3.5 kHz. Hornbills produced relatively low amplitude, short duration bark-like vocalizations. Pigeons and doves also produced continuous repetitive calls for territory advertisement (Figs 1a, b). Aquatic birds also produced contact calls and territorial calls, e.g., Watercock *Gallicrex cinerea* used a wide-band resonating repetitive call (Fig. 1c).

Blue-throated Barbet *Megalaima asiatica* produced loud vocalizations in the breeding season (summer) from prominent positions on the upper canopy of tall trees. The vocalizations phonetically rendered as *poo..crooo…poo..croo…* were composed of discrete phrases. The signal seems to be produced for territory advertisement and courtship. Great Barbet *Megalaima virens* also used loud, repetitive, monotonous *pio… pio…* calls for territory advertisement/courtship (Fig. 1d). Large-tailed Nightjar *Caprimulgus macrurus* produced loud resonating calls during the breeding season for territory advertisement (Fig. 1e). In the presence of a female, the male produced another type of call probably for mating purposes which seemed like a frog call rather than a bird call. In non-passerine birds, other categories of vocalizations were territory advertisement, alarm, contact, flight, and begging calls.

Studies on vocalizations of Indian non-passerine birds are limited to a few species (Ishtiaq and Rahmani 2005, Kumar and Sharma 2011). Overall, the investigations showed that non-passerines use a limited repertoire of vocalizations known as calls. These signals are innate and used for foraging, group cohesiveness, alarm, begging, and roosting, thus they are essential for survival. These are an ideal model to understand the ecology and evolution of acoustic communication of birds. However, the main focus of avian bioacoustic studies has been mainly on song and oscine birds, while non-passerine birds were often neglected. Thus, there is a gap in information that needs to be filled through research.

Vocalizations of passerine birds: Vocal repertoire of most of the songbirds studied comprised of song and six to ten types of calls, such as alarm (in some species two types), territorial, begging (in some species two or more than two types), roosting, emergence, contact, provisioning, mobbing, distress, greeting, and flight calls.

i. *Vocal repertoire in Brahminy Starling*

Bioacoustic analysis of the recordings of the Brahminy Starling revealed that it uses different types of vocalizations (Fig. 2, Table 1) for communication. On the basis of their physical characteristics, these signals can be classified into calls and songs.

a. *Alarm calls*: Based on the predation pressure and acoustical features, two distinct categories of alarm calls (i.e., type-1 and type-2) have been identified in this species. In the presence of predators such as sparrowhawk, crow, tree-pie, owl, rhesus macaque, and cat in the close vicinity of individuals or nest sites, the birds used type-1 calls. It was a harsh, wide band (frequency band width: 4.51±0.185 kHz; n=18), stereotyped signal. Most individuals produced call notes (elements) with almost equal temporal gaps. The min., max., range, and dominant frequencies of these calls were 1.03±0.023, 5.56±0.115, 4.51±0.185 and 7.78±3.75 kHz, respectively. The average duration of elements was 0.637±0.079 sec preceded and followed by average temporal gap of 1.35±0.189 sec. During high predation pressure, especially when a predator approached close to the nest, type-2 calls were observed. These were monosyllabic, stereotyped. and low amplitude calls often with narrow descending frequency range. Results indicate that the type-1 calls were quite distinct from type-2 calls, both in physical characteristics (Table 1) and structure (Fig. 2).

b. *Distress calls*: Both, adults and juveniles were observed using these calls when captured by a predator or handled during mist-net capture. Since the physical characteristics of distress calls of adults and juveniles were similar, these were clumped for analysis. Nestlings and fledglings produced these calls during predator attacks or when handled for observations. These signals, phonetically rendered as *cheearr...chseerr...,* were composed of a wide range of frequencies. The min., max., range, and dominant frequencies of these calls were 0.85±0.118, 8.49±0.324, 7.62±0.224 and 4.81±0.731 kHz, respectively. The average duration of elements was 0.768±0.034 sec, and the call interval was 1.89±0.38 sec.

c. *Begging calls*: These vocalizations were produced by nestlings/fledglings. Three different types of calls were identified. On the basis of physical characteristics, these can be classified as type-I, type-II and type-III (Table 1, Fig. 2). Type-I calls were simple, stereotyped, wide-band without overtones, and composed of monosyllabic elements. The min., max., range, and dominant frequencies of these calls were 5.19±0.085, 8.36±0.051, 3.16±0.042, and 7.35±0.164 kHz, respectively. The average duration of elements was 0.13±0.002 sec and the call interval was 0.59±0.062 sec. Type-II calls were monosyllabic with rapid frequency modulations, wide-band and without overtones. The min., max., range, and dominant frequencies of these calls were 0.98±0.164, 9.09±0.096, 8.02±0.064, and 4.48±0.267 kHz, respectively. The average duration of elements was 0.071±0.001 sec and the call interval was 0.876±0.094 sec.

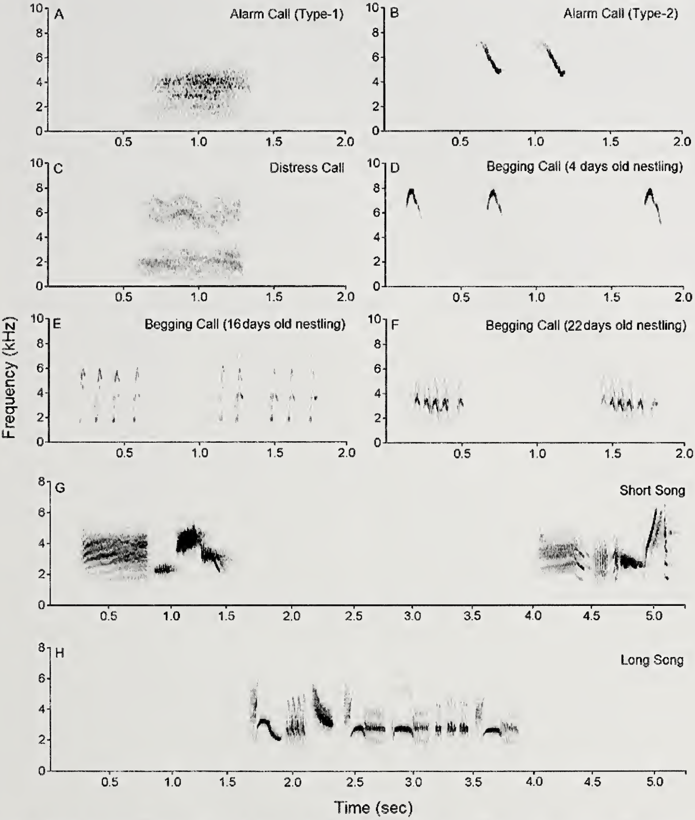

Fig. 2: Spectrograms of different types of calls and song in Brahminy Starling, (a) Alarm call type-1 used in low predation pressure, (b) Alarm call type-2 used in high predation pressure, (c) Distress calls, (d to f) Three different types of begging calls recorded in different age groups of nestlings, (g) Short song, and (h) Long song

Besides begging calls type-I and type-II, the nestlings were observed using another call. This call was observed only in the late nestling phase. It was composed of simple, monosyllabic, stereotyped wide band elements. The min., max., range, and dominant frequencies of these calls were 1.95±0.078, 6.115±0.14, 4.148±0.14, and 3.34±0.037 kHz, respectively. The average duration of elements was 0.235 ±0.012 sec and the gap was 1.9±0.115 sec. The context of production was also not clear. It seems that these calls are either the developmental phase of another vocalization or have a specific purpose – further investigations are needed.

Apart from the different types of calls, the Brahminy Starling used song for territory advertisement and/or mate acquisition. Adults produced song during the breeding season mostly in the morning (05:00-09:00 hrs) and evening (17:00-19:30 hrs). Individuals were observed singing from exposed branches of trees. The song of Brahminy Starling is discrete and composed of phrases. The min., max., range, and dominant frequencies of songs (N=8, n=29), were 1.42±0.061, 5.42±0.156, 4.00±0.175, and 3.00±0.075 kHz respectively. Average duration of strophes was 0.95±0.71 sec, preceded and followed by temporal gap 6.37±0.072 (n=29) sec. Songs were produced at 8.91±0.52 (n=14) strophes per min. The average number of elements/phrase and types of elements/phrase were 4.79±0.32 and 4.24±0.183 (n=29), respectively. In some cases, the song phrases comprised up to 11 elements sung at higher rate. It seems that Brahminy Starling uses two categories of song. The first category – 'short songs' – were for territory advertisement and second category – 'long songs' – were for mate acquisition. However, detailed investigations are needed to understand the proliferation of song in this species.

The vocalizations of only a few Indian species have been studied in detail; Oriental Magpie-Robin *Copsychus saularis* (Bhatt *et al.* 2000; Kumar and Bhatt 2001, 2002), Greenish Warbler *Phylloscopus trochiloides* (Katti 2001), Red-vented Bulbul *Pycnonotus cafer* (Kumar 2004), Brown Rock-chat *Cercomela fusca* (Sethi and Bhatt 2008), White-bellied Shortwing *Brachypteryx major* (Robin *et al.* 2011), Indian Black Robin *Saxicoloides fulicatus* (Kumar 2011) and Pied Bushchat *Saxicola caprata* (Sethi *et al.* 2012). These species used different types of context-specific vocalizations for communication. Some other species such as Common Chaffinch *Fringilla coelebs*, has eight basic calls (Bergmann 1993). Adult domestic fowl and Red Junglefowl (*Gallus gallus*) have a repertoire of up to about eighteen call types (Collias 1987). Snow (1958) estimates that adult Eurasian Blackbird *Turdus merula* has seven basic call types. Pied Flycatcher (*Ficedula hypoleuca*) and Collared Flycatcher (*Ficedula albicollis*) have been reported to use twelve call types (von Haartman and Lohrl 1950). There are similar estimates for the Great Tit *Parus major* and Black-capped Chickadee *Poecile atricapillus* (Hailman and Ficken 1996), and that of the Carolina Chickadee *Poecile carolinensis* seem to be somewhat larger (Smith 1972).

Review of literature revealed that most avian species produce specific alarm vocalizations when they encounter predators (Blumstein 1999). The alarm calls include several categories of vocalizations based on the degree of predation pressure and location of predators (Ficken and Popp 1996). Some species produce a single invariant call, while others produce multiple types of calls because alarm calls convey specific information about environmental events (Blumstein 1999). Interactions between parents and nestlings/juveniles have been characterised by a number of calls, namely offspring call to get food, heat, and protection from predators, or parent call to provide offspring with information regarding food, predation pressure, and parent's location (Marler and Slabbekoorn 2004). Distress calls are often produced when captured by a predator. Many birds produce roosting calls at their roosting sites.

ii. *Complexity level of songs*

Song characteristics are highly diverse among Indian songbirds. The Common Tailorbird *Orthotomus sutorius* and Hill Prinia *Prinia atrogularis* produced a simple song made up of one to three types of elements (Figs 3a, 3b); they repeat the same syllable. Grey-headed Canary-Flycatcher *Culicicapa ceylonensis* and White-throated Fantail *Rhipidura albicollis* used three to eight types of elements in their songs (Figs 3c, 3d), while thrushes, chats, babblers and pipits produced a wide range of complex songs. For example, Brown Rock-chat *Cercomela fusca*, Red-billed Leiothrix *Leiothrix lutea* and Verditer Flycatcher *Eumyias thalassinus* produced a wide range of frequency modulated, complex shaped elements in their songs (Figs 3e-g).

In most oscine birds, song complexity serves as an honest signal of male quality (Hesler *et al.* 2011), and selection may also favour song parameters, such as song rate and song length (Garamszegi and Møller 2004; Kunc *et al.* 2005). In species with large repertoire, sexual selection might favour the evolution of structural song traits, such as whistle songs in nightingales (Kunc *et al.* 2005), believed to have evolved to attract migrating females at night [as structurally simple whistles suffer less from spectral degradation during propagation over long distance (Slabbekoorn *et al.* 2002)]. In species with a small repertoire, sexual selection may favour song length and song rate, as reported in some species such as Willow Tit *Parus montanus* (Welling *et al.* 1997), and Hoopoe *Upupa epops* (Martin-Vivaldi *et al.* 2002).

iii. *Categories of songs*

Two categories of songs were largely observed in the species of bulbuls and robins studied. However, based on this, it cannot be speculated that all Indian songbirds use two categories of songs. Species such as bulbuls sing throughout the year, while species such as robins, chats, pipits, and sunbirds sing only in the breeding season. The

Table 1: Physical characteristics of different types of calls in Brahminy Starling

Sr. No.	Physical Characteristics Types of calls	Produced by	Nature of call	Number of elements per call	Types of elements per call	Min. freq. (kHz)	Max. freq. (kHz)	Frequency Band width (kHz)	Dominant freq. (kHz)	Duration (sec)	Gap between elements (sec)
1.	Alarm Call (type-1)	Male and female under low predation pressure	Simple	1	1	1.03±0.023 (N=6, n=18)	5.56±0.115 (N=6, n=18)	4.51±0.185 (N=6, n=18)	7.78±3.75 (N=6, n=18)	0.637±0.079 (N=6, n=18)	1.35±0.189 (N=6, n=18)
2.	Alarm Call (type-2)	Male and female under high predation pressure	Simple	1	1	4.47±0.56 (N=6, n=18)	7.19±0.015 (N=6, n=18)	2.74±0.085 (N=6, n=18)	4.66±0.45 (N=6, n=18)	0.188±0.009 (N=6, n=18)	2.39±0.321 (N=6, n=18)
3.	Distress Call	Fledgling and adults	Simple	1	1	0.85±0.118 (N=2, n=6)	8.49±0.324 (N=2, n=6)	7.62±0.224 (N=2, n=6)	4.81±0.731 (N=2, n=6)	0.768±0.034 (N=2, n=6)	1.89±0.38 (N=2, n=6)
4.	Begging call (type-I)	Nestlings (mainly 3 to 8 days old)	Simple	1	1	5.19±0.085 (N=5, n=14)	8.36±0.051 (N=5, n=14)	3.16±0.042 (N=5, n=14)	7.35±0.164 (N=5, n=14)	0.13±0.002 (N=5, n=14)	0.59±0.062 (N=5, n=14)
5.	Begging call (type-II)	Nestlings (mainly 9 to 18 days old)	Simple	2-7	1	0.98±0.164 (N=5, n=14)	9.09±0.096 (N=5, n=14)	8.02±0.064 (N=5, n=14)	4.48±0.267 (N=5, n=14)	0.071±0.001 (N=5, n=14)	0.876±0.094 (N=5, n=14)
6.	Begging call (type-III)	Nestlings (19 to 24 days old) and fledglings (mainly during first one month after fledging)	Simple	2-7	1	1.95±0.078 (N=5, n=14)	6.115±0.14 (N=5, n=14)	4.148±0.14 (N=5, n=14)	3.34±0.037 (N=5, n=14)	0.235±0.012 (N=5, n=14)	1.9±0.115 (N=5, n=14)

N= number of individuals; n= total number of calls analyzed (2 to 3 calls per individual were analyzed)

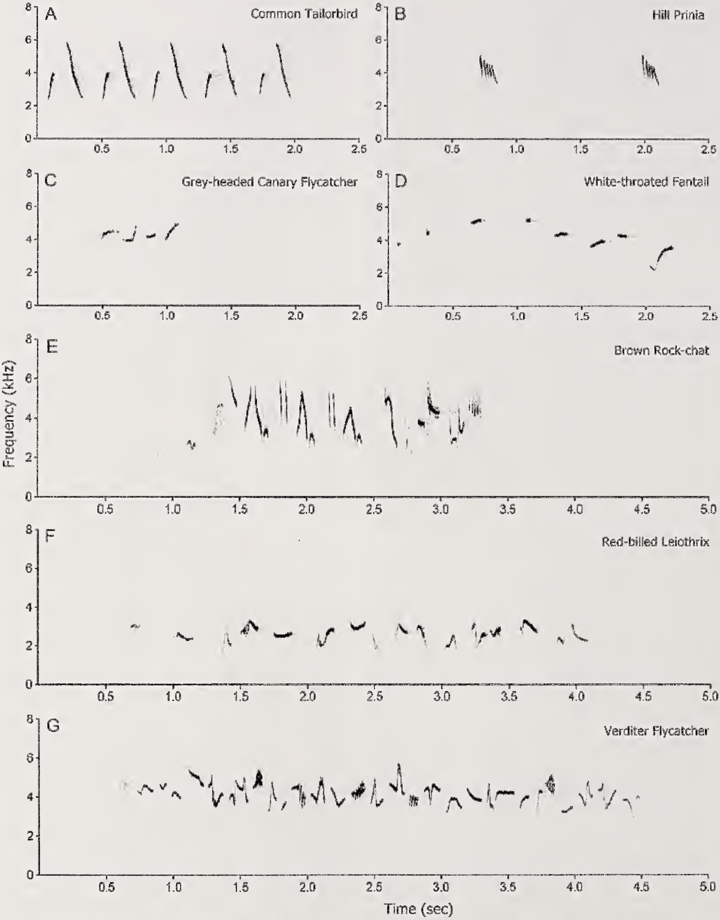

Fig. 3: Spectrograms of different types of songs. (a, b) Short and simple songs, (c, d) Medium songs usually made up of 3 to 6 types of elements per phrase, and (e to g) complex songs

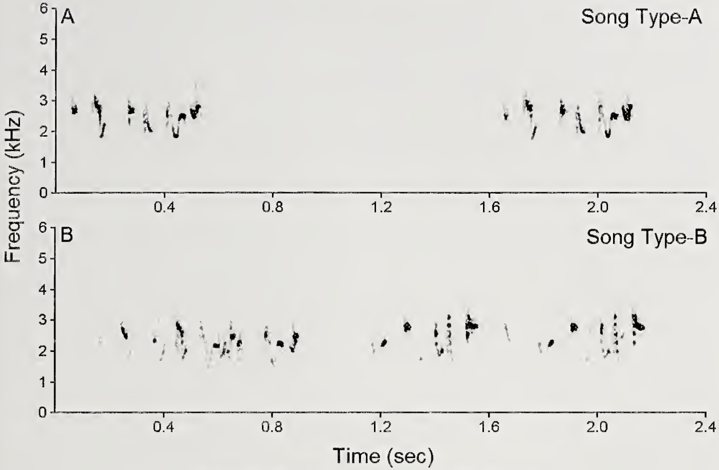

Fig. 4: Spectrograms of two categories of songs in White-eared Bulbul

White-eared Bulbul *Pycnonotus leucotis* sang throughout the year with increased singing bouts in the breeding season. Most of its songs (named Type-A) were discrete, made up of phrases (Fig. 4). The average min., max., range, and dominant frequencies of these vocalizations were 1.42±0.043, 4.26±0.072, 2.9±0.08, and 2.54±0.035 kHz (n=18), respectively. The average duration of phrases was 0.576±0.019 sec, preceded and followed by average temporal gap of 3.98±0.429 sec (n=18). Most phrases were composed of elements ranging from 5 to 7 (average 5.77±0.129, n=18) elements per phrase, mostly dissimilar in structure. Occasional sharing and/or repetition of the elements were also observed. The rate of production was 8 to 12 phrases per min. The song was also used during foraging, greeting, and pre-roosting. Occasionally produced Type-B songs were also observed. These were about three to four times faster than Type-A songs (Fig. 4), however, the rate of overall production was low. Two to six phrases were produced with an irregular inter-phrase gaps. The gap between phrases and elements was lower than Type-A songs. These songs were observed always in the presence of another individual (most probably the female). However, sex in the present study could not be determined due to lack of sexual dimorphism in this species. It seems that these songs were for mate acquisition.

The Indian Black Robin *Saxicoloides fulicatus* (Family Muscicapidae) produced mostly discrete songs, composed of strophes or phrases (structural units) preceded and followed by temporal intervals, known as Type-A songs. These songs were simple, stereotyped, spontaneous, and common. Sometimes individuals produced another category of songs known as Type-B songs. These were rare, female-oriented and more complex than Type-A (Kumar 2011). The Oriental Magpie-Robin *Copsychus saularis* also used two categories of songs, which were distinguished by their acoustical features and context of production. 'Discrete Songs' were common throughout the breeding period (March to July) and sung daily from prominent song posts by territory owner males. The males were observed singing 'Continuous Songs' in the presence of females (Kumar 1999). Bulbuls (Family Pycnonotidae) used Type-A songs (discrete, simple, loud, stereotyped, mostly spontaneous, and commonly sung throughout the year) to maintain pair bonds and Type-B songs (rare, complex, with irregular inter-phrase gaps with low amplitude and mate-oriented), for mating purposes. Song was used in both inter- and intra-sexual contexts (Kumar 2004).

Like Indian birds, some non-Indian passerines have been reported to sing two or more acoustically distinct song classes,

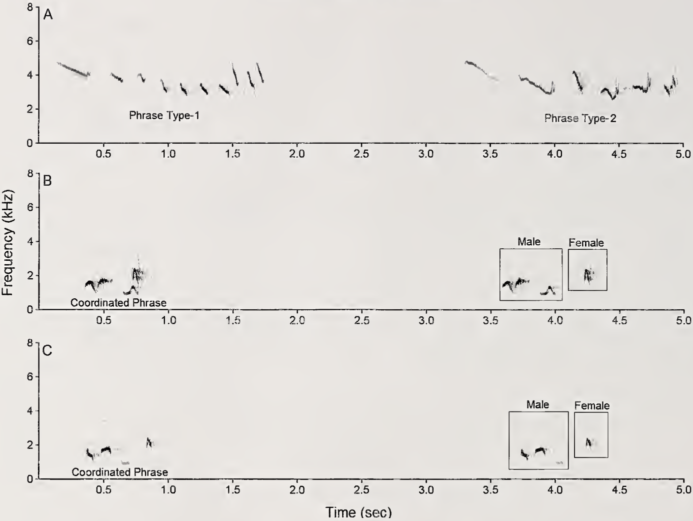

Fig. 5: Spectrograms of songs produced by females, (a) Solo song of female Oriental Magpie-Robin, (b) Duet song of Rusty-cheeked Scimitar-Babbler, and (c) Duet song of Spot-breasted Scimitar-Babbler

e.g., Dark-eyed Junco *Junco hyemalis* (Titus 1998), Field Sparrow *Spizella pusilla* (Nelson and Croner 1991), Yellow-throated Vireo *Vireo flavifrons* (Smith *et al.* 1978), Yellow-rumped Cacique *Cacicus cela* (Trainer 1987). In some other species, e.g., European Blackbird *Turdus merula* (Dabelsteen and Pedersen 1990), European Robin *Erithacus rubecula* (Dabelsteen *et al.* 1997), Common Whitethroat *Sylvia communis* (Balsby 2000) and Song Sparrow *Melospiza melodia* (Anderson *et al.* 2008), songs are described as 'broadcast songs' (like Type-A songs of Indian Robin) and 'soft songs' (such as Type-B songs of Indian Black Robin) also termed as 'quiet song', 'twitter song' or 'whisper song' in previous studies (Anderson *et al.* 2008). The first category songs of these species were loud and conspicuous, and second category songs were soft, low amplitude and rare, used in different contexts, such as courtship, male-male aggression or both (Anderson *et al.* 2008). However, in Indian Black Robin, Type-B songs were used only for mating/courtship (Kumar 2011). Some species of North American wood-warblers (Parulidae) also sing two categories of songs (Spector 1992). The first category is often simple and highly stereotyped, sung at relatively low rates and near females, while the second category songs were usually more complex and variable, sung at higher rates and in male-male interactions (Bolsinger 2000). In contrast with the wood-warblers song system, Indian Black Robin used simple and stereotyped songs for territory/pair-bond maintenance and complex, varied songs for mating (Kumar 2011).

Some hypotheses have been postulated to explain the evolution of song categories in birds (Nelson and Croner 1991). It is hypothesised that all song types (phrases) within the vocal repertoire of a species may have the same purpose. Evolution of a large number of song types in a species may be favoured by both inter- and intra-sexual selection. Large repertoires may effectively repel rival males by appearing to represent the presence of several singing males. Large repertoires might also be favoured by females during mate selection (Catchpole 1980). Another hypothesis assumes that different song categories/song types within a repertoire contain different information (Trainer 1987). Different song types are sung in different behavioural contexts, and thus appear to provide different information to listeners.

iv. *Female participation in singing*

In Indian birds, females in some species, such as bulbuls and mynas sing quite commonly, while it is a rare phenomenon in species such as Oriental Magpie-Robin. The female of this species sings occasionally (Kumar and Bhatt 2002). Solo and duet singing of Oriental Magpie-Robin was observed during this study: the duet song was without temporal coordination. Song features were similar to that of males. The song was short, simple, and discrete, composed of phrases made up of several elements which differ in acoustical characteristics and structure (Fig. 5a). The purpose of song seems to defend territory and to synchronize breeding. Some birds like scimitar-babblers produced well-coordinated duet song made up of phrases. In each phrase, the first two elements were produced by the male and the last by the female, such as in Rusty-cheeked Scimitar-Babbler *Pomatorhinus erythrogenys* and Spot-breasted Scimitar-Babbler *Pomatorhinus erythrocnemis* (Figs 5b, 5c).

Based on studies conducted on temperate birds, it was believed that songs are produced exclusively by males, with a few exceptions (Marler and Slabbekoorn 2004; Riebel 2003). Contrary to this, in the tropics, females also frequently sing either solo like males, or coordinated songs with males (Farabaugh 1982). A few hypotheses have been proposed to understand the differences between singing behaviour of females in tropics and tropical habitats (Slater and Mann 2004). Temperate and tropical birds experience different environmental pressures and life-history trajectories that may possibly account for the evolution of diverse behavioural patterns. Temperate zone species are often migratory, with short breeding seasons that create relatively brief periods of intense activity and distinct sex roles that may include major asymmetries in song production, reproductive behaviour, and territory defence. In contrast, many tropical species experience relatively little temporal environmental fluctuation, leading to sex role convergence, which may possibly favour female song, monogamy, shared territory defence and duetting (Morton 1996).

CONCLUSIONS

Vocalization is an important means of communication in birds and plays a vital role in their life cycle. Most birds produce species-specific vocalizations, which can be used for species identification, description of new species, census and field survey. Discovery of new species, assessment of taxonomic rank and phylogenetic analysis is possible through vocalizations. Many new species have been identified due to their distinct vocalizations. Some morphologically similar species of birds can be easily separated by their vocalizations. Many wild species are elusive, hidden in impenetrable vegetation, or high in the canopy. Recording and playback are frequently used to attract individuals to the observer so that they may be identified visually, or to lure them towards traps/mist-nets. The relationship between songbirds and their habitat is reciprocal, and birds provide an excellent means to assess ecological changes. Birds usually occupy a diverse range of ecological niches and are sensitive bio-indicators. Conservation of songbird diversity can protect many other elements of biodiversity. Unfortunately, such studies on Indian birds are limited, while in Europe and America scientists are working for the last five decades, providing deep insights into the evolution of songs/calls in temperate birds. It is believed that most tropical birds exhibit social systems quite different from temperate species. Communication systems of most tropical Indian birds cannot be properly understood if studies are based on the information available on temperate birds. So, extensive long-term investigations are needed for the characterisation and documentation of the vocal repertoire of Indian birds.

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FOOD-NICHE PARTITIONING AMONG SYMPATRIC KINGFISHERS IN BHITARKANIKA MANGROVES, ODISHA

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The study, conducted from January to May, 2011, attempted to understand the potential mechanisms that may play a role in food-niche differentiation among four sympatric kingfishers, i.e. Small Blue, Collared, Black-capped, and Brown-winged kingfishers in Bhitarkanika mangroves. For foraging behaviour, an individual was followed till it captured a prey and relevant foraging variables were recorded. A total of 53 independent prey captures were recorded for the four species of kingfishers. Perch height and foraging distance differed significantly among the four kingfisher species. All the prey characteristics, i.e., prey type, prey size, and foraging substrate showed significant variations among the species. This study revealed that each of the four kingfisher species in Bhitarkanika mangroves occupy foraging niches corresponding to their respective body size. The foraging behaviour of the smallest species, i.e., Small Blue Kingfisher, and the largest, i.e., Brown-winged Kingfisher, is similar. The foraging behaviour of the Collared and Black-capped Kingfisher is similar, but they differ in terms of prey size taken, corresponding to their respective body sizes.

Key words: Kingfisher, foraging, mangroves, prey

INTRODUCTION

Kingfishers are a cosmopolitan group of stockily built birds with characteristic colourful plumage, short neck, and dagger-like bills (Knowles and Nitchen 1995). This large and widespread family consists of 93 species worldwide, with 12 residents and one vagrant species in India (Rasmussen and Anderton 2005). They are known to inhabit a wide range of habitats, e.g., rain forests, deciduous woodlands, savannahs, arid areas, mangrove swamps, freshwater swamps, lakes, sea shores, river valleys, and estuaries. Their food varies from small fish and water crustaceans to small vertebrates, insects, and arachnids. Kingfishers are diurnal, highly mobile, wide ranging and are relatively easy to observe. Moreover, several species of kingfishers are known to coexist in a given space and hence they are a good group to study food-niche partitioning.

Sympatric species with similar resource requirements need to partition available niche space in order to coexist. The search for these mechanisms underlying such species' coexistence is a central issue of community ecology (Begon *et al.* 1990). To understand these mechanisms, it is vital to know about the food requirements, foraging habitat preferences, and how the resources are shared between these sympatric species. Reduction of food-niche overlap may occur through food partitioning by type or by size of prey, or through segregation in foraging areas (Garcia *et al.* 2005). Our study attempted to understand the pattern of food-niche differentiation among four sympatric kingfishers, i.e., Small Blue *Alcedo atthis*, Collared *Todiramphus chloris*, Black-capped *Halcyon pileata*, and Brown-winged *Pelargopsis amauroptera* Kingfishers in Bhitarkanika mangroves. Previous studies (Ashmole 1968; Costa *et al.* 2008; Kasahara and Katoh 2008; Padilla *et al.* 2007) have shown that prey size is determined by the body size of sympatric species. So sympatric kingfishers of different body sizes in Bhitarkanika were expected to show dissimilar prey size. Apart from this, there might be other inter-specific variations in foraging behaviour reflecting the influence of body size, e.g., perch height, foraging distance, and depth of water in the foraging site.

STUDY AREA

Bhitarkanika National Park (20° 30' – 20° 48' N; 86° 45' – 87° 03' E) is located in the deltaic region of Brahmani and Baitarani rivers in the Kendrapara district of Odisha. It presents a salt tolerant, complex and dynamic ecosystem that occurs in tropical and subtropical inter-tidal regions. The intensive study area consists of four forest blocks, namely Bhitarkanika, Dangamal, Mahinsmada and Ragadapatia blocks with an area of *c.* 40 sq. km. The main river flowing through the area is Bhitarkanika. Numerous creeks of different sizes are located all along the river, which are mainly fed by tidal water, so they are dynamic in nature; some of the smaller creeks completely dry out during low tide. The vegetation along the creeks mainly consists of tree species, such as

Table 1: Variables recorded on foraging behaviour of Kingfisher species in Bhitarkanika N.P. (Jan–May, 2011)

S. no	Variables	Remarks
1	Kingfisher species	Small Blue, Collared, Black-capped, or Brown-winged Kingfisher
2	Type of perch	Categorised as i) plant, ii) dry log, iii) bank, iii) artificial pole
3	Perch height	Height at which the bird perched while feeding – estimated visually in metres
4	Foraging distance	Distance travelled to catch the prey – estimated visually in metres
5	Water depth	Measured in metre at the visually determined point after the foraging individual flew away
6	Foraging substrate	The material from which food was taken; categorised as i) water, ii) vegetation, iii) tree hole, iv) mud bank, v) air
7	Size of prey	Estimated by comparing it with the bird's bill (as % of bill length) and categorised as i) small (less than the bill length of the smallest species Small Blue Kingfisher, i.e., <4 cm), ii) medium (all between small and big category, i.e., 4-8 cm), iii) big (greater than the bill length of the largest species Brown-winged Kingfisher, i.e., >8 cm)
8	Type of prey	Categorised as i) fish, ii) crabs, iii) insects, iv) mudskipper
9	Vegetation cover	% foliage cover imagining a circular plot of 5 m radius around the bird at 5 m distance from the perch site of the bird

Heritiera fomes, *Sonneratia apetala*, *Avicennia officinalis* and *Excoecaria agallocha*. Among shrubs, *Brownlowia tersa* is the most abundant species along the creeks.

METHODS

Foraging behaviour

The study was conducted from January–May 2011. Observation protocols were standardised after making *ad libitum* observations in the field (Altmann 1974). Efforts were made to record foraging observations from all types of habitats. The creeks were surveyed by country boats and individuals of the target species were actively searched. Observations were done opportunistically and once an individual of the target species was located, it was followed till it captured a prey and relevant foraging variables were recorded (Table 1). To reduce the problem of pseudo-replication, no further data was collected on the same species within 500 m of that site after recording an observation. All the data were recorded verbally into a dictaphone.

Analyses

Inter-specific variations in microhabitat variables, such as perch height, foraging distance and vegetation cover were tested using one-way ANOVA (Zar 1999). Prior to analyses, vegetation cover and foraging distance values were square root-arcsine and log (x+1)-transformed respectively.

To test for differences in prey characteristics, prey type, prey size, and foraging substrates across species, non-parametric Fisher's Exact Test of probability (Siegel and Castellan 1988) was used as the sample sizes were low. Correspondence analysis was conducted to visualise the kingfisher species on a multi-dimensional space in relation to the prey characteristics.

RESULTS

A total of 53 independent prey captures were recorded for the four species of kingfishers during the study period (Table 2).

Microhabitat variables

Perch height differed significantly (ANOVA: $F_{3,49}$= 5.153, P = 0.004) among the four species of kingfishers, with the mean perch height of Small Blue Kingfisher *Alcedo atthis* being the lowest and that of Brown-winged Kingfisher being the highest (Fig. 1a). The foraging distance, i.e., the distance covered by a species to capture a prey also differed significantly (ANOVA: $F_{3,49}$ = 7.520, P = 0.000). Difference in water depths used for capturing prey was tested only for Small Blue and Brown-winged Kingfishers, since the other two species did not pick prey from water. It did not vary significantly between the two species (t-test, t=0.539, df=25, P = 0.594). The vegetation cover used by the four species did not show any significant difference (ANOVA: $F_{3,49}$= 0.926, P = 0.435). Post-hoc tests revealed that the distance covered by Small Blue and Collared Kingfisher for foraging is less than Black-capped and Brown-winged Kingfisher (Fig. 1b).

All the variables were not used to visualise a multivariate niche, as two species had no observation for one of the variables (water depth) and the four species did not differ significantly in the vegetation cover they used. In order to visualise the overall foraging niche-partitioning of the four species along the two variables (perch height and foraging distance) which differed significantly across the four species, individual observations were plotted along these two axes (Fig. 2). Based on the biplot, it is evident that Small Blue and Collared Kingfisher occupy relatively smaller foraging niches than Black-capped and Brown-winged Kingfishers (Fig. 2).

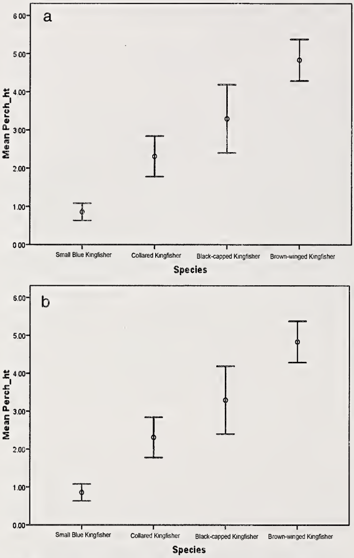

Fig. 1: (a) Perch height (mean ± 1SE), (b) foraging distance (mean ±1 SE) used for foraging by the four species of kingfishers in Bhitarkanika mangroves (Jan–May, 2011)

Among the prey characteristics, prey type differed significantly among the four species of kingfishers (Fisher's exact test, $P < 0.05$). Small Blue and Brown-winged Kingfisher seemed to prefer fish more than other prey types (Fig. 3a). The Brown-winged Kingfisher feeds on mudskippers and crabs. The diet of Collared and Black-capped Kingfisher mainly consists of insects and crabs, respectively. Size of prey captured by each species also differed significantly (Fisher's exact test, $p=0.005$). Small Blue Kingfisher was observed to forage on small and medium prey, and a few large prey (Fig. 3b). Collared and Black-capped Kingfisher captured smaller prey than Small Blue and Brown-winged Kingfishers. Brown-winged Kingfisher foraged more on large prey than the rest of the three kingfisher species. The use of different foraging substrates among the four species of kingfishers also differed significantly (Fisher's exact test, $P<0.05$). Small Blue Kingfisher was seen foraging entirely in water (Fig. 3c). Brown-winged Kingfisher also preferred water as foraging substrate. In contrast, Collared Kingfisher mostly foraged in mud banks, vegetation, and tree holes to some extent.

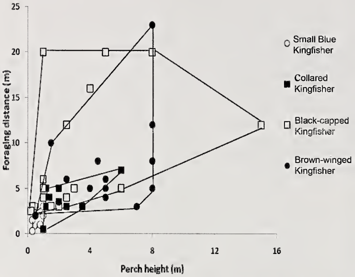

Fig. 2: Foraging-niche of the four species of kingfishers in terms of perch height (m) and foraging distance (m) in Bhitarkanika mangroves (Jan–May, 2011)

Table 2: Summary of microhabitat variables affecting the foraging behaviour of each species of kingfishers in Bhitarkanika mangroves (Jan–May, 2011)

Species	Microhabitat variables				N ind
	Perch height	Vegetation cover	Foraging distance	Water depth	
Small Blue	0.86 ±0.6	0.53 ±0.2	1.98 ±1.1	0.41±0.4	9
Collared	2.31 ±1.5	0.54 ±0.2	3.78 ±1.8	0	9
Black-capped	3.29 ±3.6	0.52 ±0.2	8.44 ±6.6	0.06 ±0.2	17
Brown-winged	4.83 ±2.3	0.42 ±0.2	7.53 ±5.4	0.87 ±1.0	18
ANOVA, P	0.004	0.435	0.000	-	53
F	5.153	0.926	7.520	-	
Df	3, 49	3,49	3,49	-	

N ind - total no of total independent foraging observations

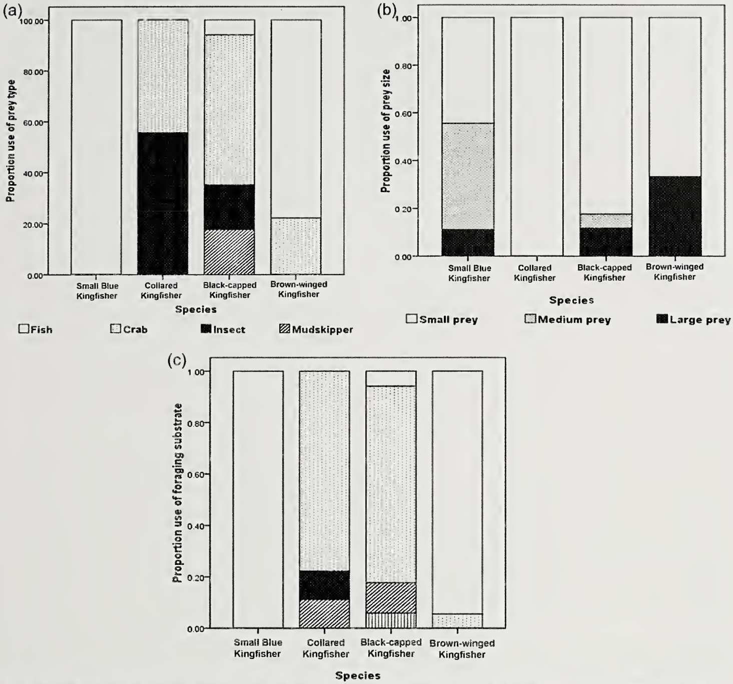

Fig. 3: Proportional use of (a) prey type (b) prey size and (c) foraging substrate by the four species of kingfishers in Bhitarkanika N.P., i.e., Small Blue Kingfisher (n=9), Collared Kingfisher (n=9), Black-capped Kingfisher (n=17), Brown-winged Kingfisher (n=18) (Jan–May, 2011)

Black-capped Kingfisher used four types of foraging substrates, most frequently mud banks, followed by air, water, and vegetation (Fig. 3c).

Correspondence analysis of prey characteristics resulted in one dimension (Fig. 4), which explained 91.9% variation in the data (Table 3). The axis reflected change in prey type from fishes to insects to crabs and mudskippers as we move from the negative to the positive end. Similarly, the axis represents a gradient in prey size, with higher scores indicating intake of smaller prey. While the use of water as a foraging substrate is indicated by lower scores, increasing score is associated with greater use of mud bank. Therefore, the species on the negative side of the axis, i.e., Small Blue and Brown-winged Kingfisher are associated with capturing fish from water (Fig. 4), whereas species placed in the positive part, i.e., Collared and Black-capped Kingfisher have higher association with intake of mudskipper, crab, and small prey from mud banks.

DISCUSSION

This study reports variation in foraging behaviour among the four kingfisher species in terms of microhabitat variables and prey characteristics, and this variation can be related to the body size of each species. The mean perch height and foraging distance covered by the species showed positive

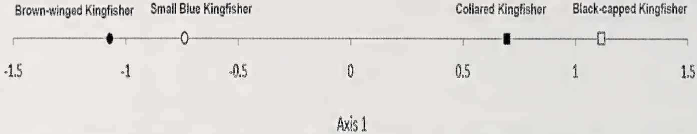

Fig. 4: Plot of the first axis of correspondence analysis (CA) ordination (91.9% of the variation) based on prey characteristics in Bhitarkanika mangroves (Jan–May, 2011)

correlation with body size. The size of the foraging niche of each species also corresponds to body size. The two smaller species, Small Blue and Collared Kingfisher, occupy comparatively smaller foraging niches than the larger species, Black-capped and Brown-winged Kingfisher. Being the smallest species, Small Blue Kingfisher is able to catch small prey and perches in lower strata of vegetation than larger kingfishers. On the contrary, the larger species, Black-capped and Brown-winged, need to catch larger prey to support their energy requirement, and therefore perch higher to be able to cover a larger area for prey. Moreover, diving from a higher perch is advantageous to gain the momentum to be able to dive into deep and/or rapid water for the larger species (Kasahara and Katoh 2008).

Similar pattern in foraging behaviour and the body size of kingfishers has been documented in previous studies. Monadjem *et al.* (1994) found that Giant Kingfisher *Megaceryle maxima* (41–46 cm) and Pied Kingfisher *Ceryle rudis* (25 cm) favoured perch-sites 2 m high, whereas the smaller species Half-collared Kingfisher *Alcedo semitorquata* (18 cm) favoured perches <2 m in height. Another study by Bonnington *et al.* (2008) along a branch of the Kilombero river in Southern Tanzania revealed that Giant and Pied Kingfisher favoured foraging areas with higher perch-sites, and deeper and wider river stretches, and Half-collared and Malachite Kingfisher *Alcedo cristata* (14 cm) preferred lower perch-sites near shallower, narrower river stretches. Kasahara and Katoh (2008) also studied the food niche differentiation between Small Blue Kingfisher (16 cm) and Greater Pied Kingfisher *Ceryle lugubris* (41–43 cm) along the Chikuma river in central Japan and found that the smaller species, i.e., Small Blue Kingfisher foraged frequently in small channels with shallow and calm water; on the contrary Greater Pied Kingfisher hunted mostly in the main channel, where the water was deep and fast-flowing.

Table 3: Respective scores of one dimension for each category of prey characteristic variables in correspondence analysis for the four kingfisher species in Bhitarkanika mangroves (Jan–May, 2011)

Category	Scores Dimension 1
Fish	-1.79
Mudskipper	0.87
Crab	0.61
Insect	0.30
Small prey	0.58
Medium prey	-0.16
Large prey	-0.43
Water	-2.07
Mud bank	1.64
Tree hole	0.06
Vegetation	0.26
Air	0.01

The foraging behaviour of the smallest species, i.e., Small Blue Kingfisher, and the largest species, i.e., Brown-winged Kingfisher, is similar. They segregate in terms of prey size, which is reflected by the respective body sizes, i.e., Small Blue, the smaller species feeding more on small and medium sized prey and the larger species, i.e., Brown-winged, feeding on larger prey. Again both Collared and Black-capped feed on crabs and insects from mud banks. Probably, being the larger species, Black-capped explores other prey types as well, e.g., fish and mudskippers. Collared Kingfisher was seen preying entirely on small prey. A good portion of the diet of Black-capped Kingfisher also consisted of small prey. So this study reports that prey size partitioning between Small Blue and Brown-winged Kingfisher leads to differentiation in prey type and microhabitat use in the same area. This segregation of prey size seems to be associated with the requirements of each kingfisher species corresponding to their body sizes. Thus, foraging-niche partitioning allows these two sympatric kingfisher species to co-exist.

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COMMON BIRDS OF ANDAMAN ISLANDS WITH SPECIAL REFERENCE TO INTRODUCED BIRDS

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We surveyed the common birds on eight human inhabited islands of the Andaman Island group, and identified 15 species as the most common bird species on the basis of abundance and extent of distribution. Of these, the introduced species – House Sparrow *Passer domesticus* (19.8% abundance) and Common Myna *Acridotheres tristis* (9.8% abundance) – were the most abundant species, and were distributed in human associated habitats. Out of 188 transects walked, the White-bellied Swiftlet *Collocalia esculenta* and Red-whiskered Bulbul *Pycnonotus jocosus* were recorded in more than 100 transects.

Key words: common birds, introduced birds, Andaman Islands

INTRODUCTION

Commonness is a relative concept and varies as global, local, relative and observed, or sample abundance (Preston 1948). It varies according to habitat and temporally. Many different factors that may determine rarity or commonness have been considered (Preston 1948). According to Grytnes *et al.* (1999), a species is defined as rare or common based on its abundance and extent of distribution; they have pointed out problems of defining rare and common species. Davidar *et al.* (1996) noted that rarity of bird species in the Andaman Islands is not because of external threats, but probably because of their intrinsic ecological requirements, biology, and limited size of the island.

The Andaman and Nicobar Islands are rich in avifauna, with more than 270 species reported from the islands (Sankaran and Vijayan 1993), of which 29% are endemics. Nineteen species were introduced to these islands in the early 20th century (Kazmierczak 2000; Lever 1987; Mohanraj *et al.* 1999; Sankaran and Vijayan 1993). Of these, only the Common Myna *Acridotheres tristis*, House Sparrow *Passer domesticus*, Indian Peafowl *Pavo cristatus*, Grey Francolin *Francolinus pondicerianus*, Blue Rock Pigeon *Columba livia*, and House Crow *Corvus splendens* now survive in these Islands. Some of these introduced species are believed to have caused disturbances to native bird species and other biodiversity.

This study was undertaken to identify the common bird species on human inhabited islands of the Andaman group, and to explore to what extent the introduced species have spread throughout the islands bird communities. Preliminary observations showed that the introduced birds have not been able to go deep into the Andaman jungles, such as Jarawa reserves, and are absent from large stretches of forest. However, many of them have successfully colonised human habitations and the natural habitats near the habitations. Hence, we restricted our study to human habitations, and natural habitats near human habitations.

METHODOLOGY

The study was conducted in eight human inhabited islands of the Andaman Island group (12° 30' N; 92° 45' E), namely South Andaman, Middle Andaman, Baratang, North Andaman, Ross Island, Little Andaman, Neil Island, and Havelock (Fig.1). Surveys were conducted from July 2008 to March 2010 employing line transect method (1km/1hr). A total of 188 transects were surveyed in six habitats: urban, village, disturbed forest, coastal, undisturbed forest near human habitations, and wetland.

Commonness of a species was calculated based on the observed or sample abundance and considering the number of detections of each species during the study (Preston 1948). To study introduced species, each bird species was accounted for separately in transects and their activities such as breeding, roosting, distribution, wherever possible, were explored. Available literature of each introduced species was also collated.

RESULTS AND DISCUSSION

In all, 12,329 individuals of 127 species of birds were recorded during the study. Among the habitats, highest numbers of species (63) were recorded in wetlands and the lowest numbers (20) were recorded in urban areas (Fig. 2). Of the total wetland species, 24 were winter migratory waders. Based on their respective abundance, we considered 15 species as 'most common' (Table 1). Of these, the first two and the fourth species were introduced species: House Sparrow (19.8%), Common Myna (9.8%), and Blue Rock

Pigeon (7.9%) respectively. These three species were distributed in all the main islands of the Andaman Islands (Table 2). Some widely distributed bird species in the Andaman Islands are Common Sandpiper *Actitis hypoleucos* (60 detections on transects), White-breasted Kingfisher *Halcyon smyrnensis* (63 detections), and the endemic Andaman Coucal *Centropus andamanensis* (52 detections) with less abundance. Introduced birds of Andaman Islands were strongly associated with human disturbed area. Of the total observations, 39.2% of bird sightings were of introduced species. Among them House Sparrow (51.27%) was the most dominant (Table 2). Common Mynas and House Sparrows were the most successful introduced birds in these islands. Other widely distributed 'most common' native species include Red-whiskered Bulbul, Large-billed Crow, and White-bellied Swiftlet (Table 1), contributing more than 5% species abundance. A brief account of the surviving introduced species is given below.

1. Common Myna *Acridotheres tristis*

The Common Myna was intentionally introduced by Colonel R.C. Tytler in Port Blair on South Andaman immediately after the settlement of a penal colony in 1858 (Lever 1987). Wood (1924) indicated that Common Mynas were released on Ross Island during 1880. Presently, free-ranging populations are established over most of the Andaman Islands. However, this species has not established well on large islands, such as Middle Andaman and Little Andaman.

Roosting areas of Common Myna in Andaman Islands were located in mangroves and vegetated sites in town centres and villages. Disturbed forests provide an excellent environment for mynas. In Port Blair, these species roost on two or three trees located in the centre of the city and in mangroves near Sippighat. They roost communally with other species such as Red-breasted Parakeet *Psittacula alexandri* and House Crow. In Port Blair, roosting trees were shared by Large-billed Crow *Corvus japonensis* and House Crow

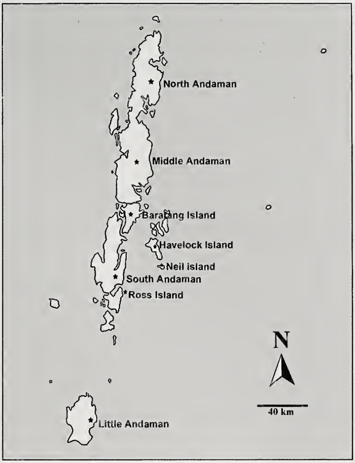

Fig. 1: Map of Andaman Islands showing surveyed islands

Table 1: Common bird species recorded in Andaman Islands from July 2008 to March 2010

No	Common Name	Scientific Name	Abundance (%)	Detections	Present in No. of transects
1	House Sparrow	*Passer domesticus**	19.8	552	87
2	Common Myna	*Acridotheres tristis**	9.8	528	95
3	White-bellied Swiftlet	*Collocalia esculenta*	8.6	259	112
4	Blue Rock Pigeon	*Columba livia**	7.9	67	24
5	Red-whiskered Bulbul	*Pycnonotus jocosus*	6.2	374	134
6	Jungle Crow	*Corvus macrorhynchos*	5.2	277	90
7	Red-breasted Parakeet	*Psittacula alexandri*	2.4	78	40
8	Lesser Sand Plover	*Charadrius mongolus*	2.3	20	10
9	Cattle Egret	*Bubulcus ibis*	2.0	50	26
10	Brown Shrike	*Lanius cristatus*	1.9	188	73
11	Common Redshank	*Tringa totanus*	1.9	29	18
12	Whimbrel	*Numenius phaeopus*	1.7	8	8
13	Lesser Whistling-Duck	*Dendrocygna javanica*	1.7	14	9
14	Red Collared-Dove	*Streptopelia tranquebarica*	1.7	35	26
15	Andaman Teal	*Anas albogularis***	1.7	10	9

* Introduced species, ** Endemic species

Table 2: Current distribution of six introduced bird species in Andaman Islands in 188 transects surveyed

No	Species	Present in No. of transects	Current distribution	% Among introduced species
1	House Crow	16	SA	3.92
2	Common Myna	95	SA , NA, BT, RI	24.4
3	Indian Peafowl	4	RI	0.55
4	House Sparrow	87	SA, MA, NA, BT, HV, NL, LA, RI	51.27
5	Grey Francolin	1	SA	0.08
6	Blue Rock Pigeon	24	SA, MA, NA, BT, HV, NL	19.8

Note: SA=South Andaman, NA=North Andaman, BT=Baratang, RI=Ross Island, MA=Middle Andaman, HV=Havelock, NL=Neil Island, LA=Little Andaman

C. splendens. Tsunami affected mangrove trees and coconut trees provide excellent nesting sites for Common Myna and Asian Glossy Starling *Aplonis panayensis* (a native species). In Andamans, Common Myna *Acridotheres tristis* mainly nested on the crown of dead coconut trees and mangroves (snags) in tidal wetlands and coastal areas. It also nested in buildings. This species has the potential to compete with other species such as parakeets and Asian Glossy Starling for roosts and nests.

2. House Sparrow *Passer domesticus*

The House Sparrow was introduced twice in South Andaman Islands during 1882 and 1895 (Lever 1987). Now they have spread to almost all the inhabited Andaman Islands along with human settlements. They nest on buildings, street lights, roofs of houses, and shutters of shops. These birds roost colonially in towns, villages, and in bushes located near wetlands.

3. House Crow *Corvus splendens*

The House Crows were intentionally introduced to Port Blair during 1862 and 1864 by Col. R.C. Tytler due to their scavenging habit, but failed to survive on these islands (Lever 1987). It is reported that House Crows reached Port Blair less than a decade back accidentally by ship and are currently restricted to Port Blair. The species shares feeding, nesting, and roosting sites with the Large-billed Crow. It may compete with the Large-billed Crow and other local species, but more information is needed to substantiate this.

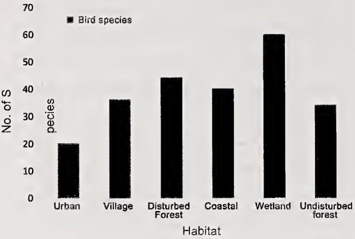

Fig. 2: Number of bird species recorded in each habitat of Andaman Islands along the 188 transects surveyed

4. Grey Francolin *Francolinus pondicerianus*

The Grey Francolin was introduced to South Andaman during 1890 and is seen only in Port Blair. During this study, only four individuals were observed at one location. The impact of this species on other fauna is unknown.

5. Indian Peafowl *Pavo cristatus*

The Indian Peafowl was introduced on Ross Island by the British in 1868. The species was decimated during the Japanese occupation (1942–43), but after the liberation of the archipelago, more were imported (Lever 1987). Currently, fewer than 10 birds survive on Ross Island.

6. Blue Rock Pigeon *Columba livia*

Blue Rock Pigeon were introduced to South Andaman and Car Nieobar in 1898 (Kazmierczak 2000; Lever 1987). The species has established well in the Andaman Islands, especially in Port Blair and Rangat. It lives in urban areas. Its impact on other species is unknown.

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BLYTH'S TRAGOPAN *TRAGOPAN BLYTHII* (JERDON 1870) IN EASTERN NAGALAND: PEOPLES' PERCEPTION

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A questionnaire survey was done in five eastern districts of Nagaland to collate information on Blyth's Tragopan *Tragopan blythii* (Jerdon 1870), the State Bird of Nagaland, during April 2009 to December 2010. Surveys were conducted in 269 villages, and in each village 4–5 elderly persons (*Gaunburas*), and hunters were interviewed to collect information on the occurrence, status, ecology and peoples' perception on Blyth's Tragopan in their forests. An attempt was made to compare the indigenous ecological knowledge pertaining to this species with that reported in literature. Inhabitants of 83 of the 269 villages surveyed, reported the presence of Blyth's Tragopan in their forests; in 25% of the villages, this species was not uncommon and in 27% of the villages, tragopans have locally disappeared. Information on the ecology of this species provided by locals and that in literature was similar. The study revealed that most of the villagers are aware of the decline of biodiversity in their area. Several villages have earmarked Community Conservation Areas (CCAs, which are community protected reserves) and banned hunting of wildlife, including Blyth's Tragopan. It was found that most of the CCAs require technical support with respect to wildlife conservation strategies and alternate livelihood options for the local people. This species appears to be common in a few localities in Kiphere district of Nagaland, and an in-depth ecological study is suggested, which would provide data required to develop long-term conservation plans for this species in the region.

Key words: Blyth's Tragopan, Community Conservation Area, conservation, northeast India, pheasants

INTRODUCTION

Blyth's Tragopan *Tragopan blythii* (Jerdon 1870) is distributed in India, Bhutan, Myanmar, and parts of China; in India, it is restricted to the forested hill tracts of northeast India (BirdLife International 2008; Ghose *et al.* 2003). The estimated global population of this species varies from 2,500–10,000 birds, and its density may vary from 0.56 to 4.3 birds/sq. km (BirdLife International 2008). Its estimated population in Nagaland is 400 (Zeliang 1980). It is reported that Blyth's Tragopan is declining owing to widespread forest degradation and hunting pressure in parts of its distributional range (Choudhury 2001; Islam and Rahmani 2004). Due to small, declining and scattered sub-populations within a severely fragmented range and hunting pressure, this species is categorised as Vulnerable by IUCN (BirdLife International 2008). In India, it is accorded the highest legal protection subsequent to its listing in Schedule I of the Indian Wildlife (Protection) Act, 1972.

Sálim Ali Centre for Ornithology and Natural History (SACON), Coimbatore, in association with Nagaland Empowerment of People through Economic Development (NEPED), Kohima, has been working in the eastern districts of Nagaland since 2007. A major objective of this study was to strengthen the efforts of local communities in conserving natural resources, including wildlife. As part of this study, we documented the indigenous knowledge on flora and fauna, data on occurrence, status, and peoples' perception of Blyth's Tragopan, the State bird of Nagaland. In the present paper, we attempt to compare the knowledge of locals pertaining to this species with that reported in literature.

MATERIAL AND METHODS

Study Area

Northeast India, which is a part of the Indo-Myanmar faunal sub-region, is one of the 34 global biodiversity hotspots (Myers *et al.* 2000). Nagaland (25° 06'–27° 04' N; 93° 20'–95° 15' E) is one of the north-eastern states of the Indian Union. The study was conducted in five eastern districts of the state, namely Phek, Tuensang, Mon, Kiphere, and Longleng. The entire area is hilly with elevation ranging between 194 and 3,842 m above msl, the highest peak being Saramati (3,842 m above msl) in Kiphere district. Monthly

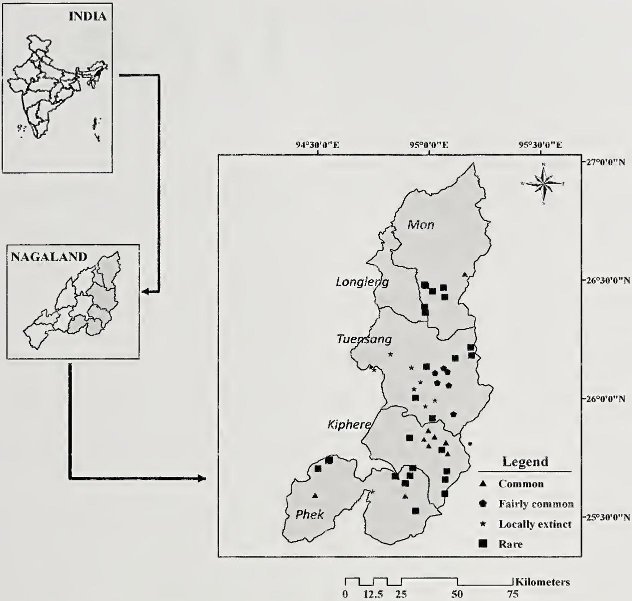

Fig. 1: Eastern districts of Nagaland showing current distribution of Blyth's Tragopan based on a questionnaire survey

mean temperature of the area ranged from 16 °C to 31 °C and in a few locations it may drop to about 4 °C during December and January. Eastern Nagaland receives rains primarily during June–September and the average annual rainfall of the area ranges from 2,000 to 2,500 mm. The major indigenous tribes inhabiting the district are Chang, Sangtam, Khiamungan, Yimchunger, Sumi, Konyak, Pochuri, Chakhesang and Phom, and all of them are reported to be originally hunter gatherers (Ganguli 1984; Joshi 2001; Sanyu 2008). *Jhum* or slash and burn cultivation is the most common agricultural practice found in these districts.

Field Methods

A questionnaire survey was done in the villages of the five districts of Nagaland from April 2009 to December 2010. As one of the major goals of the SACON-NEPED project was to encourage locals to establish community conservation areas, surveys were restricted to villages with considerable forest cover, 269 villages of the 464 villages of the districts. About 4–5 elderly persons, *Gaunburas* and hunters were interviewed in each village, and information on the occurrence, status, ecology, and peoples' perception of Blyth's Tragopan inhabiting their forests was recorded. Interviews with villagers were conducted by a local resource person known as Facilitator of Community Conservation (FCC) in the presence of at least one of the authors of this paper. The FCCs are local village youths trained by SACON-NEPED in biodiversity conservation, and they played a crucial role in liaising with the villagers. In all, the services of 29 FCCs were utilised during this study. Photographs of Blyth's Tragopan (male and female) were shown to villagers during the interview. Location (latitude-longitude) of most of the villages was recorded using a GPS (12 Channel, Garmin). Based on the statements of the locals, population status of the species was categorised as common, fairly common, rare, and locally extinct. Sightings/calls 10+ times by a person in one year was considered as common, 5–10 as fairly common and <5 as rare, and the status categorisation of the bird was done following consensus among persons interviewed in the village. Birds not seen/heard in an area by villagers for more than five years were considered as locally extinct. Information provided by people on Blyth's Tragopan was compared with that available in literature such as Ali and Ripley (2001) and BirdLife International (2008).

RESULTS

The presence of Blyth's Tragopan was reported to occur in the recent past (namely, within 5–10 years) in 83 (31%) of 269 villages sampled (Table 1). This species is known in 14 local (dialect) names, and local names such as *Wühthürang* (*Langa* dialect, Yimchunger tribe, Tuensang and Kihere districts, 18 villages) and *Uhngang* (*Sangtam* dialect, Sangtam tribe, Tuensang district, 14 villages) are widely used.

The status and distribution of Blyth's Tragopan in the five eastern districts of Nagaland is shown in Figure 1. Tuensang had the highest number of villages that reported this species; none of the 24 villages interviewed in Longleng district reported it. The tragopan was somewhat common in about 25% of villages, and in 22 (27%) villages it had disappeared (Fig. 2). Among the 22 villages with no recent reports of tragopan, 21 were in Tuensang district (Table 1). In 13 villages, tragopans were reportedly common; of these, 10 were in Kiphere district.

In general, it appears that Blyth's Tragopan is rare in the eastern districts of Nagaland. A comparative account of published information on aspects of its ecology and that reported by the indigenous people of eastern Nagaland is provided in Table 2. This study revealed that Blyth's Tragopan is distributed in a wide range of elevation, i.e., 600–2,800 m above msl in the eastern districts of the state. Of the 83 villages with tragopan reports, 67 (80.8%) were located above >1,000 m above msl. The highest number of villages with the report of this species was located >1,800 m above msl followed by 1,400–600 m above msl category (Fig. 3). All villages where the Blyth's Tragopan was reported common were found at elevations of 1,100–2,200 m above msl. Eighty out of eighty-three villages which reported Blyth's Tragopan informed that this species inhabits primary forests. According to the local Nagas, these undisturbed primary evergreen have never been under *jhum* cultivation. In 33 locations, this species was observed in secondary forests, i.e., *jhum* lands left unattended for over 15 years.

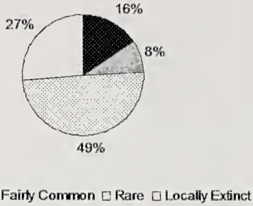

Fig. 2: Status of Blyth's Tragopan in 83 villages of the eastern districts of Nagaland with a recent history of its occurrence

Locals reported that the Blyth's Tragopan feeds on many species of flower buds, berries, fruits, and seeds. People of 58 villages reported fruits as a major food of this species, 53 villages considered seeds and grains as its food, and inhabitants of 23 villages thought that this species also feeds on insects. People of 66 villages reported that tragopans breed during March–June. Seventeen villages reported that this species did not breed in their forests since nests were not located. People of four villages said that this species nests in forests above 2,000 m above msl and 12 villagers reported that they breed in primary (evergreen) forests. People of 13 villages reported that it nests on the ground in tropical evergreen forests.

Table 1: Status of Blyth's Tragopan in the eastern districts of Nagaland based on questionnaire survey

District	Villages surveyed	Positive response	Status			
			Locally Extinct	Rare	Fairly Common	Common
Tuensang	75	35	21	7	7	0
Phek	59	21	1	18	0	2
Mon	73	12	0	11	0	1
Kiphere	38	15	0	5	0	10
Longleng	24	0	0	0	0	0
Total	269	83	22	41	7	13

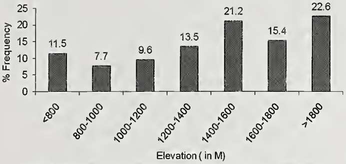

Fig. 3: Distribution of Blyth's Tragopan in various altitudinal categories of eastern Nagaland based on questionnaire survey; number of villages surveyed=269, villages with some information on Tragopan=83

Inhabitants of all villages reported that the population of Blyth's Tragopan is declining due to over exploitation (hunting) and deforestation. They also believed that deforestation brings the bird to open habitats, which makes them victims of predators and hunters. Of the 83 villages, in 58 villages tragopan feathers were used for decorative display in houses as a sort of hunter's trophy. People of 73 villages reported that they hunted Blyth's Tragopan for food, using airguns (49 villages) and traditional methods, such as snares and catapult (28 villages). People of all the 83 sampled villages were aware of the decline of Blyth's Tragopan in their area. Among the 83 villages with some information on tragopans, 76 villages have declared about 250 Community Conservation Areas (CCAs). CCA is a patch of forest owned and managed by a village. A village may have many CCAs. The size of these protected forest patches varies from a few hectares to about 10 sq. km. Self imposed ban on hunting wild animals is in place in most of the CCAs, including specific resolution to protect Blyth's Tragopan in villages such as Washelo (Tuensang district), Iponger (Kiphere), Angphang and Yakshu (Mon).

DISCUSSION

The study reported 14 local (dialect) names for the Blyth's Tragopan. The usage of numerous local names for this and several other species in this region could be due to isolation of villages for so many years due to their remoteness and animosity among communities. Head hunting was reportedly prevalent among Nagas till 1965 (Ganguli 1984). Among 83 villages with information on the species, 22 villages reported local extinction and it was reported as rare in another 41 villages (Table 1). This indicates that the status of Blyth's Tragopan in eastern Nagaland is rare and declining, which confirms the reports at global level (BirdLife International 2008).

The Blyth's Tragopan was reported to occur between 600 and 2,800 m above msl, which is wider than the reported elevation range (1,400–3,300 m above msl) of this species (BirdLife International 2008). Choudhury (1997, 2001) reported that the lowermost elevation range of this species in Nagaland is 1,400 m above msl. Reported occurrence of this species at lower elevations (600 m above msl) by locals indicates its potential occurrence in much lower elevations; further ground surveys are required to confirm this. Most of the villagers reported primary forests as the habitat of Blyth's Tragopan, which is similar to that reported in literature (Ali and Ripley 2001; Choudhury 2001; Ghose *et al.* 2003). This study also reported the occurrence of this species in a few secondary forests, which is similar to observations by Choudhury (1997, 2001) and Ghose *et al.* (2003).

Some of the information on the ecology of Blyth's Tragopan provided by local communities of eastern Nagaland was consistent with that found in literature (Table 2, Ali and Ripley 2001; BirdLife International 2008; Choudhury 2001; Ghose *et al.* 2003, 2007). Several villagers reported that this species breeds during March–June, which is close to that found in literature (April–May). Several villagers said that tragopans did not breed in their areas, and that it is possible that this species nests at higher elevations and locally move to lower elevations seasonally. In this regard, reports by four villages that this species nests in forests found above 2,000 m above msl is notable, as information on the nest of free ranging birds of this species is not available (Ali and Ripley 2001).

Table 2: Comparison of peoples' view and that found in literature on Blyth's Tragopan

Information	Peoples' views	Published information
Habitat	Primary forests (evergreen forests)	Subtropical, temperate and evergreen forests
Elevation (m)	600–2,800	1,400–3,300
Diet	Seeds, berries, fruits, and buds, insects	Seeds, berries, fruits, and buds
Breeding	March–June	April–May
Nesting	Nesting on ground in tropical evergreen forests	No nests have been found in the wild
Threat	Overexploitation (hunting) and deforestation	Deforestation, primarily as a result of shifting cultivation

The study revealed that most of the villagers are aware of the decline of biodiversity, including of the Blyth's Tragopan, in their region. Many of them showed interest in conserving them, and several villages have created CCAs and banned hunting of wildlife within the protected forest patches. As the forest patches are owned by the locals, conservation of biodiversity involving local communities would be the best possible option. Most CCAs require technical support regarding conservation strategies and alternate livelihood options.

This study has shown that the Blyth's Tragopan is distributed in most parts of the eastern districts of Nagaland, and a systematic survey is suggested to assess the status of this species in Nagaland. Literature survey shows that available information on the ecology of this species is scanty. Since the species appears to be common in Kiphere district of Nagaland, and ecological studies in this area are also suggested as it would provide pertinent ecological information for planning species conservation strategies. This study also highlights the in-depth indigenous ecological knowledge of the people of eastern Nagaland.

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HABITAT STRUCTURE AND ITS EFFECTS ON BIRD ASSEMBLAGES IN THE KALAKAD-MUNDANTHURAI TIGER RESERVE (KMTR), INDIA

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The majority of faunal studies focus on diversity and endemism on elevational gradients. It is claimed that a complex interplay of factors explains the variability of observed gradient patterns, including non-biological ones such as differences in sampling regime. Little is known of factors influencing bird community composition at local levels in tropical rainforest. Along successional gradients, habitat structure and tree species composition influence bird community structure, wherein structurally and floristically similar sites tend to have similar bird communities. In addition, canopy dwelling species have been often ignored or under sampled due to logistical problems. The present study explores variations in local bird community structure along a disturbance gradient in a tropical rainforest of the Western Ghats of India using traditional ground-based sampling in conjunction with canopy sampling.

Key words: Community structure, canopy, sampling, feeding guilds, secondary forests

INTRODUCTION

Tropical secondary forests make up one-sixth of all primary forests that were clear-felled during the 1990s (Wright 2005), and are most likely to be a dominant feature in tropical landscapes of the future (Wright and Muller-Landau 2006). This expansion of degraded and abandoned lands in deforested landscapes may have important implications for the long-term conservation of tropical forest wildlife (Daily 2001; Lindenmayer and Franklin 2002; Wright and Muller-Landau 2006). The values of areas of native regeneration and secondary growth are poorly understood, and our current knowledge base fails to predict whether these habitats will help conserve tropical forest species in the future (Brook *et al.* 2006; Gardner *et al.* 2007). Birds are one of the best known faunal groups in the tropics (Hill and Hamer 2004; Stotz *et al.* 1996) and the canopies are the most dominant feature of these landscapes. Yet canopy-based studies of birds are few and scattered, being mainly confined to the Neotropics.

Birds are an important component of the canopy habitat and many species depend on it for their survival. The analysis of patterns of vertical stratification and canopy utilisation by birds has been limited by difficulties associated with studying the top layers of the forests, and this has been the case for other groups of organisms too; e.g., ants (Tobin 1995), lizards (Reagan 1995), and bats (Kalko and Handley 2001). Limitations faced by canopy studies so far have been difficulty in access and problems of insufficient replication (Barker and Sutton 1997; Bongers 2001) and ground-based studies also lead to inaccurate generalisations and bias in the estimates of richness and abundance. Little work has been done on canopies in India, with most of the work restricted to the Western Ghats (Devy 1999; Devy and Davidar 2003; Ganesh and Devy 2000).

The vertical organisation of the avian community with respect to vegetation and habitat is essential to understanding terrestrial bird assemblages. Various factors combine to shape bird communities like resource availability, vegetation structure, and abiotic factors like temperature, light and precipitation (Cody 1985; Wiens 1989). The influence of forest height on vertical structuring of bird communities in temperate and tropical forests has been studied intensively (Anderson *et al.* 1979; Bell 1982; Cody 1974; Cody 1985; Greenberg 1981; Marra and Remesen 1997; Orians 1969; Pearson 1971; Smith 1973; Terborgh 1980; Terborgh and Weske 1969; Walther 2002a). The structure of vegetation and its density change with respect to the height of the forest (Pearson 1971; Richards 1996; Terborgh 1980). Densities of foliage are highest in the canopies and the understorey with the mid-storey having more open spaces (Bell 1982; Pearson 1971; Pearson 1975; Terborgh 1980; Terborgh and Weske 1969).

Forest height leads to change in such variables as evaporation, temperature and wind (Longman and Jenkins 1974; Richards 1996), ambient light (Endler 1993), foliage density and resources (see Pearson 1971). The above mentioned factors shape many forest communities, and species are specific to strata as they are adapted to environmental conditions of the strata they inhabit.

Species being adapted to particular foraging techniques have consequently led to varying breadths in foraging strata. The vertical distribution of foraging substrates may also cause species to have different stratum breadths (Walther 2002b). The distribution of resources can also lead to specialisation and narrow foraging strata according to resource abundance (Marra and Remsen 1997).

Forest disturbance, such as selection-felling and shade tree plantations, can generally result in decrease in stature of stands. Hence, the available habitat for birds is also reduced and may result in restructuring and even possible expatriation of habitat specialists. Keeping this in mind, this paper focuses on understanding the differences in bird community structure between habitats in relation to habitat structure, including vertical strata, by canopy sampling in conjunction with terrestrial sampling.

METHODOLOGY AND STUDY AREA

The study was carried out in the mid-elevation evergreen forests around Kakachi and Upper Kodayar in the Kalakad-Mundanthurai Tiger Reserve (KMTR) (77° 15' – 77° 30' N; 8° 16' – 8° 40' E) in the Agasthyamalai range of southern Western Ghats, India. The area is home to several endemic, rare and threatened species of plants and animals (Ramesh *et al.* 1997). The study site at Kakachi-Kodayar area is located on the saddle of a hill range running north-south. It forms a gentle undulating plateau with stands of undisturbed wet evergreen forest. Part of this area is under tea and eucalyptus plantation. The average altitude of the plateau is 1,200 m. Annual total rainfall averages about 3,500 mm and is well distributed throughout the year, with a great proportion falling during the northeast monsoon between October and December.

During 1972, the forests of the Kakachi were opened for plantation activity and timber extraction. Parts of the forests were selectively felled to raise cardamom and to supply timber for the match industry. The canopy was opened up by removing large trees such as *Cullenia exarillata*, *Palaquium ellipticum*, *Myristica dactyloides*, and *Calophyllum austroindicum*. In addition, valuable mid-canopy species were also illegally logged. Some parts of the forests were clear-felled to raise tea, coffee and eucalyptus plantations, but were abandoned without being planted. Also, the areas around upper Kodayar were clear-felled for the construction of a dam across the Kodayar river (Ganesan 2001). Hence, the Kakachi-Kodayar plateau is a complex habitat matrix of primary forests with an average canopy height of *c.* 30 m interspersed with areas of selectively-felled and clear-felled regenerating areas and is ideal for the study.

Avifaunal sampling

Six semi-permanent canopy sampling platforms were established in each of the three habitat types (primary, selectively-felled and clear-felled). To maintain spatial independence, no two stations were closer than 500 m. Point counts were carried out from these platforms and from five stations on the ground, one directly below the platform and one in each of the four cardinal directions from the platform with 100 m between each point. Timed point counts were carried out from 06:30 hrs to 18:00 hrs at each station (platform and five ground points) for two days in a season. This data was collected for seven seasons from March 2006 to February 2009. All bird registrations (sighting and calls) were recorded during point counts. Number of individuals, distance from the observer, height, behaviour, foraging tactics, light habitat, and position were also noted. All over-flying birds and uncertain identifications were removed from the analysis. To maintain independence between points (and to avoid any potential double counting) all detections >50 m from the observer were excluded from the analysis. For vertical stratification absolute height was used as it could be accurately ascertained as the platform height and tree heights in the sample locations were known.

Habitat structure

We measured all standing trees ≥10 cm DBH and enumerated ≤10 cm DBH saplings in 10 plots measuring 10 x 10 m, established at each of the 18 canopy platform locations. We only recorded trees having more than half of their stem within each plot. The canopy cover was calculated using digital photographs taken at waist height, avoiding obstruction of understorey vegetation. Results are analysed using Gap Light Analyzer v. 2.0 (Frazer *et al.* 1999).

We obtained data on the vertical distribution of vegetation density at the study site. Using SRT and descending on a rope and we passed a one-metre stick in a horizontal circle at one-metre intervals from the top of the canopy to the ground. At each height, the number of leaves touching the stick was counted. A total of 90 descents were made, with 30 in each habitat and data from all descents within a habitat was averaged (Fig. 3).

Analysis

Most census techniques do not sample animal populations perfectly, and all references to abundance in this paper refer to relative abundance derived from our sampling techniques instead of the 'true' abundance, which is unknown. Point counts in tropical forests are more effective for sampling avifauna in mature forest (Blake and Loiselle 2001). For indications of bird-sampling completeness and estimated species richness, Coleman curves were compared with estimators Chao2, ICE, and MMMean (Chao 1987; Lee and Chao 1994; Raaijmakers 1987), which are considered optimal estimators for tropical birds (Herzog *et al.* 2002; Matlock *et*

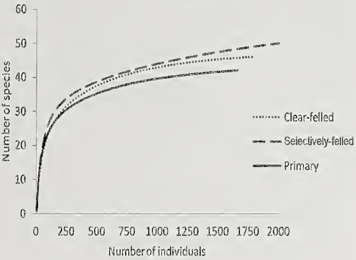

Fig. 1: Coleman curves for bird sampling in the three habitat types

al. 2002; Walther and Martin 2001). Patterns of species richness between different forest types were compared using sample-based rarefaction curves constructed using the analytical formulae implemented in estimateR (Oksanen *et al.* 2011).

Location and dispersion of frequency distributions can be calculated in a number of ways (Sokal and Rohlf 1995; Zar 1996), but the most widely used statistics are the mean and standard deviation (Fowler and Cohen 1986). We used those statistics because they were also used in a previous analysis of the relationship between the mean and the standard deviation of foraging height (Terborgh 1980; Walther 2002b). A weighted least-squares regression was used to fit a parabolic model ($y = b_2 x^2 + b_1 x^1 + b_0$) to the data, using the program R (R Development Core Team 2011) which allows a direct graphical depiction of the relationship, and it may have ecological relevance.

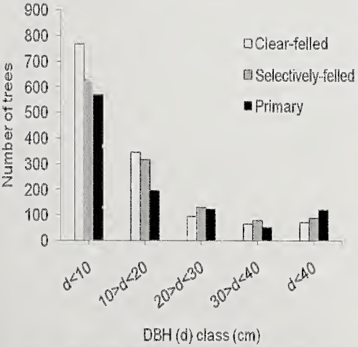

Fig. 2: Distribution of tree diameter at breast height (DBH) of clear-felled, selectively-felled and primary forests in Kakachi and Kodayar (n=174)

All community structure analyses were undertaken using square-root transformed abundance data to reduce the influence of the most dominant species, and site-standardised to account for differences in total abundance. Ordination analyses were implemented in R (Oksanen *et al.* 2011) using De-trended Correspondence Analysis on individual sites to see if there was any distinct grouping. Species were assigned to foraging and dietary guilds following Ali and Ripley (1981), supplemented by field observations.

RESULTS

Bird sampling completeness and comparative bird species richness

A total of 2,578 detections of 59 species were made over 1,464 hours point count observations from the canopy and understorey samples combined. Sampling completeness was estimated at 85-91% Clear-felled (CF), 82-88% Selectively-felled (SF), and 72-76% Primary Forest (PF) (Table 1). Overall species richness in selectively-felled areas (50) was higher than in clear-felled (46) and primary (40) forest areas, but the difference was not significant (χ^2=5.39, df=2, P=0.07) (Fig. 1).

The estimated species-richness values were taken as relative bird species-richness between sites, rather than absolute values, because the protocols were standardised across sites.

Habitat Structure

Vegetation: The tree DBH distribution differed between forest types (χ^2=69.29, df =8, P<0.001) (Fig. 2).

The height class distribution of trees <10 m and >10 m differed significantly among the forest types (χ^2=196.21, df =2, P< 0.001) with the primary and the selectively-felled areas having higher density per hectare of tall trees and clear-felled areas having greater density of shorter trees (Table 2). Percentage canopy cover was also significantly different across the habitat.

Table 1: Estimated bird species richness for the three forest types

Forest Type	Coleman rarefaction	Chao 2	ICE	MM means
Clear-felled	51.9 ±1.8	54.2 ±1.3	59.2 ±1.3	61.3
Selectively-felled	59.0 ±1.6	62.7 ±3.1	67.3 ±1.9	68.3
Primary forest	56.6 ±1.2	57.1 ±1.9	71.1 ±2.9	67.3

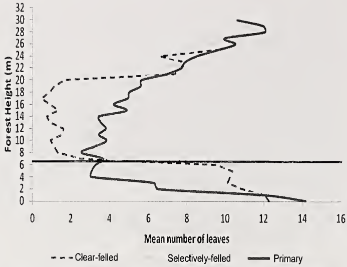

Fig. 3: Forest height versus vegetation density, i.e., the mean number of leaves (data points were smoothed by averaging over a symmetrical 3 m interval).
The thin line indicates mean density in primary forest which was 6.51±3.35 [mean ±SD]

Vertical stratification

We restricted the analysis to species that were observed in all habitats and with at least five detections in each (a total of 1,122 observations of 31 species). These species, with the exception of cryptic and nocturnal species, can be considered the most abundant species in our study area. For the measure of foraging height, the standard deviation is a parabolic function of the mean, with the maximum point close to the middle of the range of absolute height for all the habitats (Figs 4a-c).

In the primary and selectively-felled areas, vegetation density was highest in the understorey and the canopy, and lowest in the midstorey. The clear-felled areas have high vegetation density till a height of about 8 m due to luxuriant regrowth and very low density till the canopy level (Fig. 3).

Consequently, vegetation density at the mean absolute height of each species is negatively correlated with the standard deviation of the species' absolute foraging height for all the habitats (Figs 5a-c), meaning that species in dense vegetation have narrower foraging strata across all habitats. In the clear-felled areas and selectively-felled areas, there is a stronger negative relationship compared to the primary habitats, as the species in these secondary habitats have a broader foraging breath (Figs 5a-c).

Guilds

An analysis of vertical distribution of species in the four guilds showed that that the diversity of foraging guilds was also much higher in the canopy than in the other two strata for the selectively-felled and primary areas. In the clear-felled areas, due to the absence of a well defined canopy, guild membership was greatly reduced.

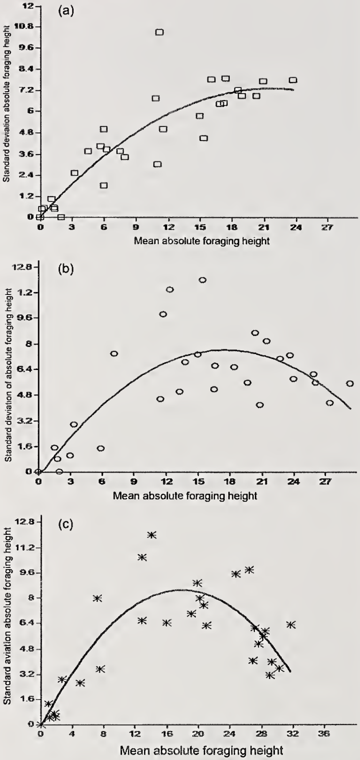

Fig. 4: Plots of the mean versus the standard deviation of absolute height for 31 tropical forest bird species.
Species with n = 5 observations depicted with squares (clear-felled), circles (selectively-felled) and astrics (primary).
All weighted least-squares regression models fits were significant at the p > 0.0001 level.

a) Clear-felled: $y=0.054x^2+ 0.67x-0.015$, $r^2= 0.80$, F=57.72, df=(2,31), $p<0.0001$
b) Selectively-felled: $y=-0.30x^2-0.90x-0.02$, $r^2=0.68$, F=30.53, df= (2, 31), $p<0.0001$
c) Primary: $y= -0.15x^2+0.97x-0.02$, $r^2= 0.74$, F=41.28, df=(2,31), $p<0.0001$

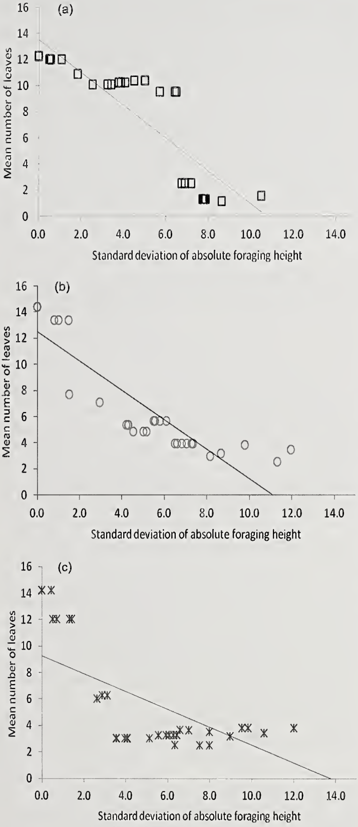

Fig. 5: Plot of vegetation density (mean number of leaves) versus the standard deviation of absolute height for 31 bird species (model I linear regression)

a) Primary: $y = -0.67x+9.27$, $r^2= 0.42$, F=22.6, df=(1,31), $p<0.0001$

b) Selectively-felled: $y=-1.22x +12.49$, $r^2=0.79$, F=120.63, df= (1, 31), $p<0.000$

c) Clearfelled: $-1.22x+13.53$, $r^2= 0.77$, F=105, df=(1,31), $p<0.0001$

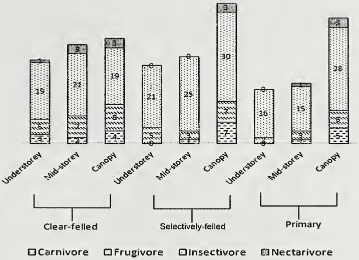

Fig. 6: Species richness of four guilds in vertical space across the three habitats

The understorey and mid-storey avifauna were predominantly insectivores in all habitats, whereas the canopy had all guilds, especially frugivores and nectarivores (Fig. 6).

To discern the patterns of guild variation, the four basic guilds were further divided according to foraging modes. This revealed that the primary forest was dominated by habitat specialists, secondary forest harboured both specialists and generalists, while clear-felled held either none, or very few, habitat specialists. Most foraging and dietary guilds that were recorded in sufficient numbers to be tested exhibited significant differences in their abundance between habitats (Fig. 7).

For example, arboreal gleaning insectivores were most abundant in the primary forest and the selectively-felled areas as the foliage volume in these areas is much higher than in clear-felled areas. Arboreal sallying insectivores also showed a similar trend. Arboreal omnivores were consistently most abundant in secondary growth habitats. Terrestrial gleaning insectivores were also more abundant in these habitats. Arboreal frugivores were attracted to the clear-felled habitats due to the abundance of drupes offered by the secondary vegetation, mainly *Elaeocarpus munronii*, *Elaeocarpus serratus*, and *Persea macrantha*.

Differences between habitats

Bird community structure was different in each of the three habitat types for all data sets, with each forest forming a distinct cluster on an MDS plot (ANOSIM global R=0.69, p=0.001; and all pair-wise habitat comparisons were significant, p=0.01) (Fig. 8). Species abundance in primary forest proved to be a poor predictor of its abundance in other habitat types. Within habitats, community dissimilarity among sites was similar for all habitat types, but slightly lower in

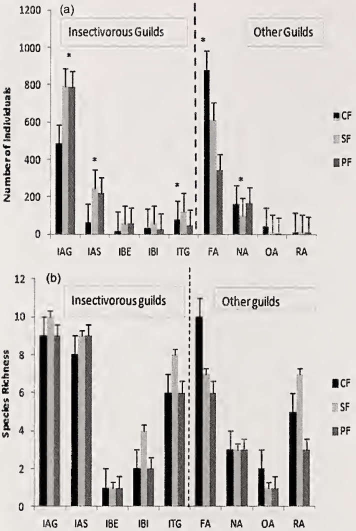

Fig. 7: Changes in the (a) abundance of birds and (b) species richness grouped by foraging and dietary guilds across habitat. [Guild codes are: IAG – arboreal gleaning insectivore; IAS – arboreal sallying insectivore; IBI – bark-searching insectivore (internal); IBE – bark-searching insectivore (external); ITG – terrestrial gleaning insectivore; FA – arboreal frugivore; NA – arboreal nectarivore; OA – arboreal omnivore; RA – diurnal raptor] Significance tests were made using Kruskal-Wallis tests, with p-values indicated by *=<0.05.

clear-felled areas. Geographic distance between sites and community dissimilarity did not show any significant relationship (Rho= -0.1, p=0.4).

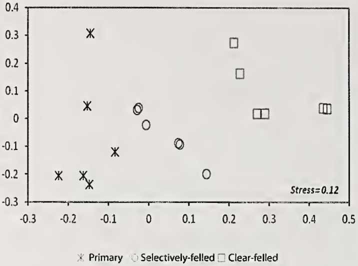

Fig. 8: Non-metric multidimensional scaling (MDS) ordinations of the bird community in three forest types. Ordination analyses are based on quantitative dissimilarity matrices.

DISCUSSION

Tropical bird community composition is constrained and determined by habitat structure (Terborgh 1985). Bird species richness and community structure is strongly correlated with closed canopy and complex habitat structure in regenerating forests (Andrade and Rubio-Torgler 1994; Blankespoor 1991; Bowman *et al.* 1990; Dunn 2004; Raman *et al.* 1998). There were statistically significant differences in vegetative structure between the forest types sampled. The primary and the selectively-felled areas were more similar than the short statured clear-felled areas. It can be postulated that the regeneration in selectively-felled areas had reached a level where the overall differences in vegetative structure, compared to the (control) primary forest, were not biologically or ecologically significant, and thus did not exert differential effects on their associated avifauna. Also important was the contiguity of our selectively-felled and clear-felled forest areas, which is critical in the re-colonisation of such forests (Lambert 1992). Contiguity or proximity increases the chance that vagrants or transient birds dispersing through secondary

Table 2: Vegetation structure in unlogged Primary, Selectively-felled and Clear-felled sites (F= One-way ANOVA)

	Clear-felled Mean ±SD	Selectively-felled Mean ±SD	Primary Mean ±SD	Statistic	df	P
Stem density/plot (>10 cm DBH)	11.42 ±5.8	10.18 ±1.27	8.21 ±0.034	F= 1.44	174	Ns
Stem density/plot (<10 cm DBH)	12.96 ±1.89	10.79 ±2.54	7.77 ±1.94	F = 33.34	174	< 0.001
% Canopy cover	87.42 ±6.53	90.07 ±4.69	92.75 ±1.49	F= 10.29	174	< 0.001

habitats will be detected (Terborgh and Weske 1969). Some authors have proposed that avian re-colonisation in such forests requires the presence of a mosaic of unlogged and selectively-logged forests (Johns 1996; Lambert 1992; Wong 1985), and is inversely related to the distance between them (Wong 1985).

We found that the primary forest canopy was species rich as compared to the mid-storey and understorey. In the tall primary forest, the vertical development of canopy structure provides a diversity of habitat elements and microclimatic conditions, which are crucial to vertical canopy use by birds. This general relationship of bird species diversity and forest height diversity is well known in forest-avian research (MacArthur and MacArthur 1961; Willson 1974). This study provides evidence that midstorey species of tropical rainforests forage in a broader stratum than understorey or canopy species. This was generally true for the primary and selectively-felled areas, but the clear-felled areas had a completely different pattern with species expanding their foraging niches. Dead leaf gleaning insectivores that are restricted to the forest floor in the primary areas were seen foraging at heights of 3–7 m in the clear-felled areas. The observed results may not hold true for rare species, as they were excluded from the analysis and phylogenetic relationships were not taken into account. It remains to be investigated if rare and other open-forest species have an influence on the foraging niches of the core avifauna in the clear-felled and selectively-felled areas through competition.

Studies have shown that relative height is a better measure of stratification in the absence of accurate height measurements and variability of forest height (Terborgh 1980; Walther 2002b). Since the sampling was carried out from the canopy, the height of the platforms was known and all detection heights were measured accurately. Stratification was not measured as stratum which is a crude measure, as it is a categorical variable. The relationship between the mean and the range for absolute height for Peruvian and New Guinean birds had the similar overall shape (see Walther 2002b), the observed relationships would have been impossible to infer without access to the canopy for detailed observations.

Many canopy species are usually invisible from the ground, especially in continuous canopy forests. The use of the platforms in conjunction with traditional ground-based sampling circumvents this problem (Anderson 2009; Walther 2003). The advantages of canopy sampling cannot eliminate the problem of pseudoreplication, especially for territorial species (Munn 1985). To minimise this, a total of 18 platforms were set up across the three habitats to ensure adequate replication and spatial coverage.

Variation in diurnal and seasonal height of foraging has been reported in Pearson (1971, 1977) and Bell (1982). This variation was not substantial enough to influence the overall relationship observed in our study which spanned over three years and seven seasons. The reasons for and the mechanisms that explain the observed parabolic relationships are discussed in Walther (2002b). With the change in structure of the habitat, it seems that species that specialise as understorey and canopy dwellers broaden their foraging niche. But not all species can show such niche plasticity and are forced out of the avian assemblages in areas of disturbance. Understorey babblers (*Rhopocichla atriceps*, *Pellorneum ruficeps*) and laughingthrushes (*Trochalopteron fairbanki*, *Garrulax delesserti*) use the dense band of vegetation found near the ground, which is difficult for sallying flycatchers such as *Culicicapa ceylonensis* and *Eumyias albicaudatus* which are found in the lower midstorey and above. Similarly, woodpeckers (Picidae) and nuthatches (Sittidae), as well as leaf-gleaning warblers (*Phylloscopus* spp.), tits (Paridae) and babblers (*Alcippe* spp.) are found throughout the mid-storey and extend into the understorey and the canopy. The foraging breaths for each species is hence a result of requirements that are found in a narrow band for understorey and canopy species, but in much broader strata for midstory dwellers (Walther 2002b).

The guild composition of the primary forest canopy was more diverse with an abundance of frugivores and nectarivores. Most bird species were confined to specific vertical foraging niches, especially understorey and canopy birds that forage in narrower vertical niches than mid-storey birds (Walther 2002b). The Square-tailed Black Bulbul (*Hypsipetes ganeesa*), Yellow-browed Bulbul (*Iole indica*), Oriental White-eye (*Zosterops palpebrosus*) and Brown-cheeked Fulvetta (*Alcippe poioicephala*) were some of the species that were seen to utilise vertical strata differently across the disturbance gradient. The change in habitat structure had a negative effect on these species as these canopy and mid-storey dwellers are more adversely affected.

Thirty-five years after being felled, the clear-felled areas we examined clearly failed to compensate for the loss of primary habitats and the habitat specialists they contain. Older areas of secondary forest may be more species rich (Dunn 2004) and hold a much higher proportion of primary forest species (see Sodhi *et al.* 2005). Even if forests are left, the post-disturbance recovery of bird communities is non-linear and slows after around 25 years, and regaining the complex microhabitats and structures required by primary forest specialists is likely to take centuries rather than decades (Raman *et al.* 1998).

CONCLUSION

Avian compositional characteristics were generally comparable for primary and selectively logged tropical rainforests, which possibly indicates advanced stages of forest regeneration. Our observation of generally undiminished bird diversity and greater abundance in the selectively-felled areas is an encouraging indication of the potential role of such forests in tropical-forest bird conservation. However, clear-felling had adverse impacts and showed reduction of rare rainforest specialist species because the forest canopy was opened up by logging, which resulted in gaps and changes in the vegetation structure, which were maintained by wind penetration and sustained harvesting of small boles for fuel-wood and building material by the local people and by elephant activity. However, these areas were used by frugivorous species because of an abundance of secondary species with drupe fruits, so they may be of seasonal importance to such frugivores.

A complex habitat matrix does have a potential role in biodiversity conservation as they may act as refugia, a seasonal resource, can help to offset species loss, and may also provide landscape connectivity. But the current conservation efforts should concentrate primarily on the preservation of standing primary forests.

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BREEDING BIOLOGY OF LITTLE EGRET *EGRETTA GARZETTA* IN KERALA, SOUTHERN INDIA

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The breeding biology of Little Egret *Egretta garzetta* was studied during 1999–2002 in Kerala, southern India. Investigations were made early in the monsoon to locate nesting colonies, and some of these selected for further study. Characteristics of the nest and eggs, incubation, and the data on hatching were recorded. In building the nests, the birds used materials ranging from 19.18 to 36.64 cm in length, from 35 plant species. Clutch size varied from 2 to 6, 4 being the most common. Hatching success was about 74%. As in adult birds, the food of the nestlings was mainly fish. Both the parents took part in feeding the young.

Key words: breeding biology, Little Egret

INTRODUCTION

Little Egret *Egretta garzetta* (Order Ciconiiformes, Family Ardeidae) is a snow white bird frequenting a variety of wetlands such as paddy fields, marshes, jheels, rivers and tidal mudflats. It feeds on a variety of organisms which are mainly aquatic, like fishes, insects and frogs (Ali and Ripley 1968). Studies of nest-site selection by Little Egret *Egretta garzetta* have been previously conducted in subtropical North America and in southern Europe (Arendt and Arendt 1988; Kazantzidis *et al.* 1997). Little Egret, a widely seen species, is less documented except for limited data by Hilaluddin *et al.* (2003). The present study was an attempt to examine the breeding biology of Little Egret in Kerala, southern India.

STUDY AREA AND METHODOLOGY

Observations were made in breeding colonies in Kerala, at Shoranur (10° 45' 27.7" N; 76° 16' 23.2" E), Ottapalam (10° 46' 14.7" N; 76° 22' 40.8" E) and Pattambi (10° 48' 11.0" N; 76° 11' 00.3" E) in Palakkad district, at Panamaram (11° 44' 22.8" N; 76° 04' 26.4" E) and Meenangadi (11° 39' 34.4" N; 76° 10' 21.3" E) in Wayanad district, and Kizhissery (11° 10' 28.5" N; 76° 00' 00.3" E) and Melattur (11° 03' 02.7" N; 76° 16' 37.2" E) in Malappuram district from 1992-2002. The majority of observations were made in the breeding colony in a residential area at Pattambi, where the birds were familiar with people's movement and access to the nests for observation was rather easy.

In the study sites, nesting trees were numbered, and some nests were individually marked with plates, as camouflaged as possible. The nests were watched over on a day-to-day basis during the egg-laying period; at four to five-day intervals during incubation and at weekly intervals from hatching to 24 days. Regular observations on the nests were made from the top of the nearest building or vantage point using binoculars. Observations on plumage and colour of the nestlings were also made.

RESULTS

Breeding Season

The Little Egrets usually breeds from July to September, corresponding with the onset of Southwest monsoon. The peak nesting was in August. The last batch of fledglings left the nest by mid-October.

Location of heronries

At Shoranur, the nesting sites were on trees located near the platform of Shoranur railway junction. Nests at Ottapalam and Panamaram were in a colony with other egret species. The nests at Melattur were in the police station compound near the bus stop in the town, and the nests at Kizhissery were similarly located in the town. At Pattambi, where intensive observations were made, the four colonies were located in the town along the banks of the river Bharathapuzha. Of these, one was in a temple premise and the others near to human residences. Temples, police station and railway station were seen to be secure breeding grounds for the egrets due to the protection by the concerned authorities against direct human intrusion.

Nest-site selection and nest location

Finding a nest site is a joint effort by both sexes. After selecting a suitable site, the pair remained at the site. During nest building, the pair is seen close together, the male collecting and passing the nest material to the female who arranges the material to form the nest. The female arranges the nest materials in a crisscross fashion to form the nest; after which courtship follows, culminating in copulation.

Thereafter, the female (mostly) remained in the vicinity of the nest site, while the other flew off to collect more nest material. The nests of Little Egret were of platform type, made of a loose network of twigs, compact at the base and loose at the periphery. Most of the nest material was collected from the adjacent areas. Twigs were also collected from the nesting tree and used, but rarely.

The nests were usually built on upwardly directed forks of two to five branches, both inside and on the periphery of the crown of the nesting tree. Foliage covered the nests, and they were not usually exposed to the sky. Most of the nests were either on quaternary or smaller branches. The average thickness of the branches on which nests were placed was 18.3 cm (n=10). The number of nests per tree depends on the availability of branched forks on the tree. A huge tamarind tree that had 12 nests of Little Egret (Table 1) also supported more than 50 nests of Little Cormorant *Phalacrocorax niger*, as suitable forks were available for placing nests. The nests of Little Egret were built at 4–8 m above ground level. Of the 63 nests seen at Pattambi, the higher ones were on *Cocos nucifera* and *Thespesia populnea*, while the lower ones were on *Azadirachta indica*, *Bambusa arundinacea*, and *Pongamia pinnata*. The birds used 15 different species of trees for nesting (Tables 1 and 2).

Little Egrets also nested in colonies with other colonial nesting birds. One of the nesting colonies in Pattambi town in the temple premises was on an *Aegle marmelos* tree close to the Pattambi-Kunnamkulam road. This tree had 10 nests of Little Egret, 5 of Intermediate Egret *Egretta intermedia*, 3 of Great Egret *Egretta alba* and 14 of Little Cormorant. Large Egret occupied the top of the tree, whereas the nests of Intermediate Egret, Little Egret and Little Cormorant were placed just below, in a more or less interspersed manner. The distance among adjacent nests of the same species was less than a metre, whereas the distance with a different species was 1–2 metres. On a mango tree in the same temple premises, 12 nests of Great Egret, 6 of Intermediate Egret, 22 of Little Cormorant and 6 of Little Egret were also observed. Here also, Great Egret took the topmost position and at lower levels Intermediate Egret, Little Cormorant and Little Egret nests were interspersed.

Table 1: Little Egret nesting trees at Pattambi, 2000–2001

	Nests	Height (m)
Cocos nucifera	1	8
Syzygium cumini	1	7
Azadirachta indica	2	4
Terminalia catappa	2	5
Areca catechu	2	5
Bambusa arundinacea	3	4
Pongamia pinnata	3	4.5
Strychnos nux-vomica	3	5
Cipadessa baccifera (*Melia baccifera*)	3	5
Artocarpus heterophylla	3	5
Erythrina sp.	4	6
Mangifera indica	6	6.5
Thespesia populnea	8	8
Aegle marmelos	10	6–7
Tamarindus indicus	12	6–7

Nest material

In the study sites, the birds used nest material from 35 different plant species (n=12), and the average number of pieces used for building a nest was 89 (range 61–101). The mean maximum twig size used was 36.64 cm and the mean minimum 19.18 cm (Table 3).

Table 2: Heronries of Little Egret studied during 2001–2003

No	Location	No. of Nests (Little Egret)	Tree species	Nests of associated species
1	Pattambi	63	(See Table 1)	Little Cormorant (158); Great Egret (15); Intermediate Egret (11)
2	Ottapalam	8	*Mangifera indica*	Little Cormorant (5)
3	Shoranur railway station	40	*Pongamia pinnata*, *Thespesia populnea* and *Azadirachta indica*	Little Cormorant (52); Great Egret (1)
4	Meenangadi	15	*Mangifera indica*	Little Cormorants (22)
5	Panamaram	10	*Bambusa arundinacea*	Intermediate Egret (50); Great Egret (2); Black-crowned Night-Heron (10)
6	Kizhissery	60	*Tamarindus indicus*, *Artocarpus heterophylla*, *Mangifera indica*	Indian Pond-Heron (32); Black- crowned Night-Heron (35); Little Cormorants (32)
7	Melattur	16	*Artocarpus heterophylla*, *Mangifera indica*	Indian Pond-Heron (12); Little Cormorant (22)

Clutch size

The eggs are generally pale sea green. Clutch size of 3 and 4 was most common. Clutches containing 6 eggs were occasionally observed (Fig. 1).

Incubation

The first egg was laid 5–6 days after starting the nest building. Incubation started with the laying of the first egg. After laying the egg the nest was never left unattended except on severe disturbance. The incubation periods, recorded for 60 eggs, ranged from 19–24 days (mean 21.8 ±1.5 days). Both the parents incubate the eggs and usually there were four switches in duty at an interval of 2.5 to 3 hours during the day. During incubation, the bird changes its sitting position every 30–45 minutes. While incubating, the bird kept its feathers pressed to conserve its body heat for the eggs or raised then to facilitate passage of air to dissipate the heat, according to the need. They rested their head on the rim of the nest while incubating.

Egg mortality

The eggs that failed to hatch were those that survived the incubation period, but did not hatch because of either being unfertilized or due to the death of embryo before completing development or other such causes. Egg mortality is defined here as the number of eggs lost and the number that did not hatch as percentage of the total number laid. An important reason for the loss of eggs was due to their falling from the nest during heavy wind and rainstorms. The remaining 22 eggs were lost for reasons such as predation by crows, falling from nests and nest desertion. Disturbance from human approach to the nest tree also made the incubating bird take off in a hurry, leading to the fall of eggs. On some such occasions, crows were seen raiding the nest and preying upon the eggs during their absence.

Table 3: Characteristics of nest material of Little Egret

Nest No.	Total no. of twigs	Maximum size (Mean)	Minimum size (Mean)
Nest-1	61	29.6	18.5
Nest-2	88	36.7	25.7
Nest-3	91	35.1	17.5
Nest-4	81	37.4	15.3
Nest-5	93	36.1	19.3
Nest-6	98	33.6	12.8
Nest-7	100	37.5	15.4
Nest-8	77	40.8	17.0
Nest-9	93	37.8	13.4
Nest-10	94	36.0	12.5
Nest-11	101	39.7	32.6
Nest-12	95	39.4	30.2
Mean	89.33	36.64	19.18

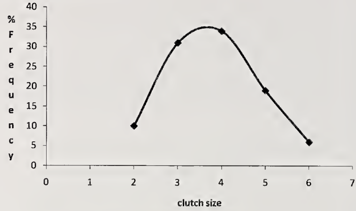

Fig 1: Clutch size and their frequency in Little Egret

Hatching success

Of the 84 eggs under observation, 62 hatched. The hatching success, the number of eggs hatched per total number of eggs laid, was 74% (Table 4). Asynchronous hatching is seen in Little Egret. The newly hatched chicks were naked, weak, and with bulging abdomen. Empty eggshell was removed from the nest by the attending parent immediately after hatching.

Young and Parental care

The nestlings (up to 14 days) had pin contours with down feathers on their neck region, dorsal tract, ventral tract, femoral tract and rectrices. The beak, tarsus, and toes were slaty. In the fledging stage (15–30 days), the first seven primaries were well-developed, whereas primaries 8–10 were still growing. The secondaries were full-grown in fledglings. In sub-adults (3–4 months), the beak and tarsus were greyish black and had bluish green lore. The feet of the bird were yellow up to the distal end of tarsus.

The chicks are always guarded by one of the parents 18–20 days. After that the parents perched at some distance and guarded the chicks for another four to five days. Thereafter, the chicks were left unattended and the parents come back to the nest only to feed them and for roosting. A guarding heron did not allow any bird, of the same or different species, to come or perch close to the nest and would

Table 4: Clutch size and Hatching in Little Egret

Little Egret	Mean	Std Deviation
Clutch size	4.42	0.84
Eggs hatched	3.26	0.93
Chicks lost	0.95	0.71
Eggs lost	1.16	0.69
Successful fledging	2.32	0.75
Hatching success	0.74	0.16

chase them away antagonistically. Chicks fallen from the nest were left to their fate by the parents.

For the first few days, the adults regurgitated the food on the nest floor. The parents also assisted the chicks in feeding if the food item was unwieldy for the chick. As the chicks grew older, they begged for food, grabbing the beak of the parents forcibly at its base and pulling it down making the parent regurgitate. During this process, the food items directly entered the beak of the chick. Boluses of regurgitated food were also seen falling out of the mouth of the parent bird. The boluses, 13 samples, showed that the food of chicks consisted of fish (91.3% by number), amphibians (1.4%), crustaceans (1.4%), insects (4.10%), and miscellaneous items (1.9%). The most important prey species was *Macropodus cupanus* (126 by number) accounting for 34.4% of total by number. Another important prey item was *Puntius amphibius* (74 in number) accounting for 20.2% of total.

The older chicks got food quicker than the younger ones. Even as the chicks started fledging, the parents continued to come to the nest site to feed the fledglings. The parents were at times seen avoiding the older chicks, aged 24 days or more. This probably would increase the survival chance of the chicks that had still not left the nest. Also, it may induce the chicks to leave the nest and fly around independently, and ultimately leave the colony. Some of the chicks, i.e., fledglings which could fly freely but had still not left the colony, were observed sitting on adjacent trees in the nesting area, and feeding on insects.

DISCUSSION

The starting of the breeding season with the onset of Southwest monsoon may be helpful to ensure sufficient food for the nestlings during their growth and development. The amount of food fed daily was 385 gm for chicks aged 10–20 days (Hafner *et al.* 1993). Fishes and other food items become available in the wetland habitats of the study area, during the monsoon. During the Southwest monsoon in Kerala, rivers and other aquatic habitats get flooded. The floodwaters bring in various aquatic organisms to the different wetlands. Moreover, the breeding of dragonflies and amphibians also coincides with the onset of the monsoon. During heavy rains, egrets in breeding plumage are usually seen in paddy fields and jheels where the water depth is suitable for wading.

Nest site selection depends on obtaining sufficient food to the nestlings and the security of young and breeding birds. This may be the reason why they select proximity to aquatic habitats, especially rivers, to nest. For example, the egrets breeding at Panamaram, were nesting at an elevated area surrounded by water on all sides, of the river Kabani. Such location probably offers maximum protection to the young. Nesting of Little Egret at Shoranur railway station premises may also indicate that the location gives high protection from direct human disturbance, and possibly also from predators or other natural threats.

Regarding the nesting trees, these birds prefer trees that possess a lot of forked branches. In *Tamarindus* trees, the twigs are strong and branched. So the nests can be built even on small and slender branches located near the periphery of the canopy. Nest building on quaternary or the next lower branches may ensure security from large predators and human interference. Both sexes were found taking part in nest building; the male collected the material while female built the nest. Such division of labour has been reported in Western Reef-Egret *Egretta gularis* and Eastern Cattle-Egret *Bubulcus coromandus* (Blaker 1969). The roosting sites of Little Egrets are distinct from nesting sites. In Western Reef-Egrets, the roosting tree was also used sometimes for nesting if the tree provide safety and sufficient food is available during the nesting season (Parasharya and Naik 1988).

In the present study, the Little Egret was found breeding only during the Southwest monsoon while Prasanth *et al.* (1994) reported breeding in other seasons. They also reported that the nests of Little Egret breeding in Southwest monsoon had lesser length and depth than those in other seasons.

Parental care and active defence of the nest is very clear in this species. While defending the nest, eggs and nestlings, the birds make *waku-waku* calls and aggressive postures, warning the predator. The bird normally would not attack the predator until it comes directly to the nest or shows some clear sign of attack. House crows generally prey upon eggs and sometimes on small chicks, exploiting situations such as when the parents on guard move away due to a sudden disturbance. However, predation is not a serious cause for chick mortality (Hafner 1978; Hafner *et al.* 1993). Older chicks are sometimes stabbed to death by the parents from an adjacent nest (Hafner *et al.* 1993). This was also reported in Grey Heron *Ardea cinerea* (Owen 1960) and Eastern Cattle-Egret (Blaker 1969). However, such incidents were not observed in this study, perhaps due to constant guarding by the parents. But, when a fledged chick hopped around the nesting branch, the parent would have already started leaving the chicks to fend for themselves, making them prone to attack by a neighbour.

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NESTING ECOLOGY OF THE NEAR THREATENED COLONIAL WATERBIRD BLACK-HEADED IBIS *THRESKIORNIS MELANOCEPHALUS* IN BHITARKANIKA MANGROVES, ODISHA

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We present here the summary of our findings on the nesting ecology of Black-headed Ibis *Threskiornis melanocephalus* in Bhitarkanika heronry, one of the largest mixed-species heronries in India. A total count of nest trees and number of nests of all species carried over three years revealed the presence of 13,704 nests in 3,839 trees (2004), 11,249 nests on 3,237 trees (2005) and 11,819 nests on 4,221 trees (2006) in the heronry. The number of Black-headed Ibis nests was 145, 143, and 138 during the three years. This ibis was the last species to arrive and was observed forming sub-colonies. There was a significant increase in the proportion of nest materials and size as the nesting stages progressed. Nest morphometry revealed that the circumference of the nest was 155.66 ±44.33 cm and the width was 9.50 ±6.11 cm. Egg morphometry revealed that Black-headed Ibis produced larger eggs both in terms of length and mass than the other heronry species. Its clutch size was also the highest (6 ±2.16) among all the heronry species. Reproductive success was random in both space and time, their spatial location in the heronry being immaterial. Results of our analysis on vertical alignment of nests did not support the body mass-nest height hypothesis.

Key words: Black-headed Ibis, heronry, Bhitarkanika, nesting, Near Threatened

INTRODUCTION

Of the three populations of the Black-headed Ibis found globally, the East Asian population is alarmingly small, with an estimate of less than 100 individuals. The Southeast Asian and South Asian population of this species is estimated at 10,000 and 25,000 individuals each (Rose and Scott 1997) and their populations have been predicted to be declining across their range due to various reasons, ranging from habitat quality to poaching. The Black-headed Ibis is a widespread resident throughout India (Grimmett *et al.* 1998) and was recorded in Ceylon (now Sri Lanka), Burma (now Myanmar), China, South Japan (Whistler 1949), Bangladesh, and Pakistan (Ali 1977). This species prefers large marshes and jheels with wide areas of water covered with bushes and trees (Whistler 1949). It breeds in six of the 19 countries where it is distributed; this species has triggered the IBA (Important Bird Area) criteria for 13 IBAs across its range (BirdLife International 2012). In India, the species has triggered the IBA criteria for 5 IBA sites, i.e., Gudavi Bird Sanctuary, Harike Lake Bird Sanctuary, Karanji Lake, Narasambudhi Lake, and Vettangudi Bird Sanctuary (BirdLife International 2012). It inhabits freshwater marshes, lakes, rivers, flooded grasslands, paddy fields, tidal creeks, mudflats, salt marshes and coastal lagoons, usually in extreme lowlands, but occasionally up to 950 msl, tending to migrate locally in response to water levels and feeding conditions (Grimmett *et al.* 1998). It is vulnerable to drainage, disturbance, pollution, agricultural conversion, hunting and collection of eggs and nestlings (del Hoyo *et al.* 1992).

The Bhitarkanika mangrove harbours one of the largest congregations of breeding water birds in the country, and is one of the five largest heronries in India which hosts around 30,000 birds every year (Chadha and Kar 1999; Subramanya 1996). Eleven species of resident water birds are known to nest in this multi-species colony (Pandav 1996). The breeding birds in this mixed species colony are Asian Openbill (*Anastomus oscitans*), Great Egret (*Egretta alba*), Intermediate Egret (*Egretta intermedia*), Little Egret (*Egretta garzetta*), Eastern Cattle-Egret (*Bubulcus coromandus*), Grey Heron (*Ardea cinerea*), Purple Heron (*Ardea purpurea*), Black-crowned Night-Heron (*Nycticorax nycticorax*), Little Cormorant (*Phalacrocorax niger*), Oriental Darter (*Anhinga melanogaster*) and Black-headed Ibis (*Threskiornis melanocephalus*). The endangered Lesser Adjutant (*Leptoptilos javanicus*) and Painted Stork (*Mycteria leucocephala*) also breed in small colonies in the Park, which has recently been identified as an Important Bird Area (IBA) of India.

Long-term studies in India with the Black-headed Ibis as a focal species are limited, except for a few recent investigations (Balakrishnan and Thomas 2004; Devkar *et al.* 2006; Narayanan *et al.* 2006). We conducted this study to establish baseline data on the breeding biology, space-use patterns and food habits of this species in the Bhitarkanika

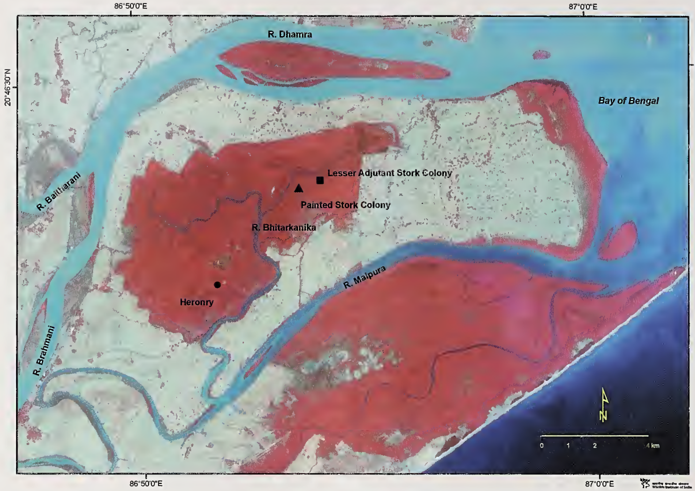

Fig 1: Map of Bhitarkanika Wildlife Sanctuary and location of the heronry inside the Park

heronry. This heronry is located on an island covered with mangrove vegetation. Enhanced foraging due to the presence of abundant foraging areas in and around the heronry in terms of wetlands and agricultural fields, decreased predation due to the remoteness of the nesting site, are supposed to be the major factors governing the large congregation of waterbirds in this heronry.

STUDY AREA

The study was conducted in Bhitarkanika National Park, Odisha. Bhitarkanika mangroves (20°04'–20°08' N; 86°45'–87°50' E), located on the east coast of India represent one of the finest remaining patches of mangrove forests in India (Fig. 1). The general elevation is between 1.5 and 2 msl; higher ground extends to 3–4 msl. The Sanctuary is bounded by the rivers Dhamara on the north, Maipura on the south, and Brahmani on the west; and the Bay of Bengal on the east. The 35 km coastline from the mouth of River Maipura till Barunei forms the eastern boundary of the Sanctuary. Annual rainfall ranges from 920 to 3,000 mm.

The heronry in Bhitarkanika is one of the oldest and largest mixed species waterbird colonies in India (Subramanya 1996). Over 30,000 birds breed every year in this heronry in a single unbroken patch of an area less than 5 ha, comprising 3,800 to 4,200 nest trees. Birds use five species of mangrove trees, namely *Excoecaria agallocha* (Guan), *Heritiera fomes* (Sundari), *Cynometra iripa* (Singada, Wrinkled Pod Mangrove), *Hibiscus tiliaceus* (Bania), *Tamarix troupii* (Jagula) for nesting in the heronry. The Asian Openbill is the most abundant nester in the heronry (66%), the least abundant being the Little Egret (0.8%).

METHODOLOGY

The study was conducted from August 2004 to December 2006. With the onset of the strong seasonal Southwest monsoon (early June), visits were made to the heronry. The entire heronry was girded into 17 blocks 50 m x 50 m each. Five trees were randomly selected from each block and marked with paint and white cloth for ease of identification. Selected trees were monitored on alternate days, and variables like tree species, nest height, nest initiation date (NID, i.e., date on which first nest materials were placed in a marked tree by a nesting pair), clutch initiation date (date of first egg being laid), egg laying dates, egg measurements, clutch size (total number of eggs per nest).

Egg morphometry was studied as follows: length (L) and breadth (B) of each egg were measured to the nearest 0.1 mm using callipers. Egg volume was calculated using the formula $V = 0.51 \times L \times B^2$ (Hoyt 1979). Nest measurements at different stages (i.e., laying, hatching, and fledgling) were measured using a measuring tape and nest material used were recorded.

Heronry Census

The census was carried out in the last week of August, just after the hatching of most birds was over. A total count of nest trees was carried out in the heronry and the tree number was painted on each. Parameters like tree species, tree height, girth at breast height (GBH), species nesting on the tree, number of nests, and nest height were recorded. Nest height and tree height were visually estimated to the nearest foot. GBH was measured with a measuring tape. The nest of the bird species was identified by observing the species guarding the nests. During the absence of both parent birds, the nest design and nest material were used to identify the species with minimal disturbance.

Behaviour

We used focal-animal sampling (Altmann 1974) to study the behaviour. Nesting birds were selected and observed for a maximum of four hours per sample. All observations of less than one minute were discarded. Copulation duration, incubation bout duration, and incubation interval time were recorded.

Breeding Biology

Once nest building started, each nest was marked with red oxide paint on a small aluminium tag below the branch that supported the nest, out of sight of the bird, with the tag bearing an alphanumeric code to identify individual nests. Nest checks were done concurrently by two observers in different parts of the colony. All observations were restricted to the cooler parts of the day (06:30 hrs to 08:00 hrs) to avoid over-heating while handling the eggs. The entire colony was not disturbed for more than one hour per monitoring. Birds left the nest when observers were within 2 to 5 m of the nest, however, they returned immediately once the observer moved away. Nest progress was followed until the chicks fledged. Nest checks continued till the last chick had fledged. We considered the young successfully fledged when they were old enough to fly across open space to trees away from the nest. Observers approached the nest along one route and left by another. This would minimise predators' opportunities to determine nest location by watching observer activities or by following scent trails.

For studying nest morphometry, nest circumference and width was measured using an inch tape. Hatching success was calculated by considering a nest as successful on hatching of a single egg. Productivity was calculated as number of chicks that survived till the fledglings dispersed from the nest. Unless indicated otherwise, errors presented in the text are the Standard Deviation of Mean (1 SD).

Analysis

Relationship between tree height and number of nests: Since the scatterplot showed a non-linear association, non-linear regression was performed. The relationship was found to follow quadratic model ($r = 0.54$, F Significance<0.01).

Species preference of nesting trees: We developed a simple and straightforward preference index (PI) to investigate nesting tree preference by water birds.

$PI = -1 \times [1 - F(obs) / F(exp)]$

Where:

F (obs) = Observed number of nests on the given tree species.

F (exp) = Expected number of nests calculated as the relative proportion of the number of tree species.

The final value ranges from -8 to +8, where 0 refers to random selection. Increasing values on positive scale indicate preference, while negative scores point to avoidance. For clarity, we predefine the index value of 1 to = 3 as zone of preference and -1 to = -3 as zone of avoidance. The scores ranging from -1 to +1 are treated as evidence for the random choice of the nesting tree.

Spatial association / co-occurrence of nesting species in the heronry: Pearson's Chi-square Statistic # $P>0.05$ (indicating spatial independence of nests) was carried out to understand the association between nesting species in the heronry. All statistical analyses were carried out using the statistical package SPSS 8.0.

RESULTS

Excoecaria agallocha was the most numerous tree species in the heronry and *Heritiera fomes* was found to be the tallest and stoutest tree species in the heronry (Figs 2a,b). The results to verify the relationship between tree height/GBH and number of nests revealed that it followed the quadratic model (Figs 3a,b). The number of nests increased with increasing GBH/tree height up to a certain value, after

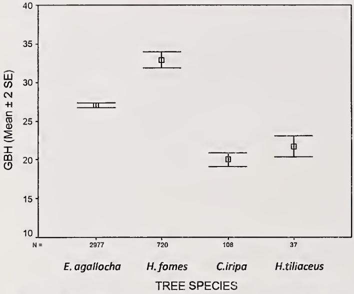

Fig. 2a: Relationship between tree species and Girth at Breast Height at Bhitarkanika heronry

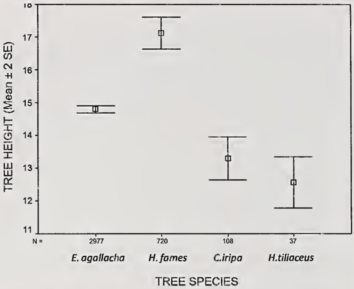

Fig. 2b: Relationship between tree species and tree height at Bhitarkanika heronry

which it declined. This is because the tall and old trees occupied the peripheral region of the heronry where most birds did not prefer to nest. Most of the birds preferred trees in the centre for nesting which were shorter and thinner compared to the peripheral ones.

Excoecaria agallocha was preferred by Black-headed Ibis to nest and the top canopy was mostly preferred for nests (Figs 5a,b). The results of the spatial association and co-occurrence of nesting species in the heronry revealed that the Black-headed Ibis showed a strong dissociation with other colonial species except for Great and Intermediate Egrets and tended to nest in sub-colonies inside the heronry (Table 1).

The Black-headed Ibis nest numbers were 145, 143, and 138 during 2004, 2005, and 2006 (Fig. 4). There has been a gradual decline in nest numbers since the first census was carried out in 1994. The Black-headed Ibis built 'platform nests', which consisted of irregularly placed, loose assemblage of plant materials. The platform nests were very simple in structure, being flat areas with a slight depression to hold the eggs. Most of the nest materials were chosen from the immediate surroundings, which result in inconspicuous or camouflaged nest. Nest profile in the heronry varied between species in relation to the body mass (Table 2), Grey Heron built the largest nest in contrast to Little Cormorant that built the smallest nest with few sticks in them. The nest size correlated to the body mass index of the nesting species, i.e., the larger the body mass of the species, the larger were the nest morphometrics.

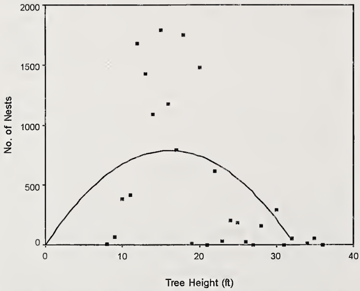

Fig. 3a: Relationship between tree height and number of nests at Bhitarkanika heronry

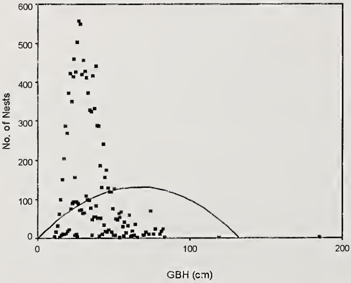

Fig. 3b: Relationship between Girth at Breast Height (GBH) and number of nests at Bhitarkanika heronry

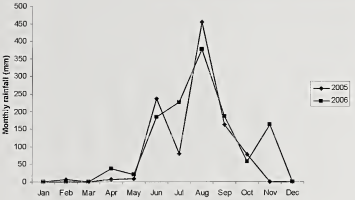

Fig. 4a: Monthly rainfall in Bhitarkanika mangroves

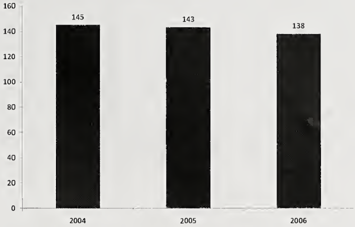

Fig. 4b: Number of enumerated nests in each month by all the nesting species

Nest material that were collected and used for nest building by the Black-headed Ibis were as follows: *Excoecaria agallocha*, *Heritiera fomes*, *Hibiscus tiliaceus*, *Tamarix troupii*, *Cynometra iripa*, *Salvadora persica*, *Salacia prinoides*, and *Avicennia officinalis*. Both dry and green plant materials were used (Fig. 6). There is a significant increase in the proportion of nest materials and size with increase in the breeding stage, i.e., laying, hatching, and fledgling stage (Table 3). Nest materials were added by both parents till the chicks fledged in all the species to provide enough space for the growing chicks to reside in the nest.

Egg morphometry studies revealed that Black-headed Ibis produces larger eggs both in length and mass, while Little Cormorant produced smaller eggs both in length and mass (Table 4). The variability in the nest initiation date to clutch initiation date revealed 8–10 days for herons and egrets, while Little Cormorants and Darters took 15–18 days to initiate the clutch. However, the Black-headed Ibis took less than one week from the nest initiation date to initiate clutch (Table 5). The Black-headed Ibis is the last species to arrive at the heronry and as soon as the birds arrive, they start building the nests and lay the clutch immediately. Asian Openbill showed a delayed clutch initiation of 30 days after nest initiation, which is presumably due to delay in monsoon. The clutch size varied between 2.5 eggs to 6 eggs per clutch across all species. Black-headed Ibis had the largest mean clutch size (6 ±2.16) followed by Darter and Little Cormorant, and Black-crowned Night-Heron had the smallest clutch size with less than 3 eggs per clutch (Table 6). Incubation started soon after the first egg laying. Black-headed Ibis and Little Egret showed the least mean incubation duration (18 and 19 days respectively) while Darter and Asian Openbill showed larger mean incubation duration (28 and 26 days respectively) (Table 7).

Productivity in terms of hatching and fledgling success was very low (<50%) for most species, especially for the Black-headed Ibis in the breeding colony. Only Purple Heron and Darter showed higher reproductive success with >50% eggs surviving till fledgling stage (Table 8). Since breeding success was known to differ between centre and edge nests (Balda and Bateman 1972; Brown and Brown 1987; Coulson 1968) the reproductive success was compared between edge nests and core nests, which revealed no difference in success rate, indicating that reproductive success was random at both space and time, regardless of their spatial location (Table 9). The results of our analysis on vertical alignment of nests did not support the body mass-nest height hypothesis, which postulates a direct positive correlation between body weight and nest height among colonial waterbirds (Fig. 7).

Table 1: Spatial association / co-occurrence of Black-headed Ibis with other nesting species in the heronry

Species	Asian Openbill	Little Cormorant
Black-headed Ibis	140.6 P = 0.753	182.1 P<0.0001

*Pearson's Chi-square Statistic # P>0.05 (indicating spatial independence of nests)

Table 2: Nest measurements of breeding species including Black-headed Ibis

Species	n	Nest Measurements (cm)	
		Circumference	Width
Grey Heron	20	217.17 ±19.05	66.17 ±11.46
Large Egret	30	172.83 ±13.0	50.3 ±4.9
Purple Heron	10	169.00 ±16.66	55.00 ±8.62
Intermediate Egret	10	168.5 ±13.86	43.5 ±4.10
Asian Openbill	20	166.1 ±16.3	52.1 ±6.3
Darter	20	162.25 ±19.15	43.25 ±7.5
Black-headed Ibis	10	155.66 ±44.33	9.50 ±6.11
Little Egret	5	144 ±7.21	45.66 ±8.50
Black-crowned Night-Heron	4	132 ±7.25	32 ±4.86
Little Cormorant	11	128 ±11.96	34 ±3.0

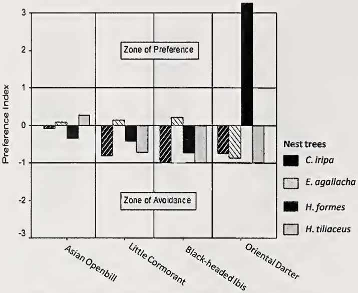

Fig. 5a: Nest tree preference of Openbill, Little Cormorant and Black-headed Ibis

Table 3: Proportion of nest materials in various nesting stages (laying, hatching and fledgling) among colonial waterbirds in Bhitarkanika heronry

Species	Friedman rank chi-square	N	Df	p-value	Result
Asian Openbill	10	20	2	0.007	Sig
Large Egret	10	20	2	0.007	Sig
Grey Heron	10	20	2	0.007	Sig
Oriental Darter	10	20	2	0.007	Sig
Purple Heron	10	20	2	0.007	Sig
Little Cormorant	10	20	2	0.007	Sig
Intermediate Egret	8	20	2	0.018	Sig
Black-crowned Night-Heron	2	20	2	0.368	Non-sig
Black-headed Ibis	6	20	2	0.05	Sig
Little Egret	10	20	2	0.007	Sig

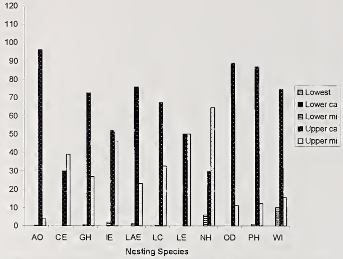

Fig. 5b: Nest location in nesting trees at the Bhitarkanika heronry

DISCUSSION

Decline of Black-headed Ibis: The nest census of this heronry was first conducted in 1994 (Bivash Pandav, pers. comm.), and the Black-headed Ibis numbers are showing a gradual decline over the years. The Black-headed Ibis is considered to be declining at a slow to moderate rate across its range (BirdLife International 2012). On a global level, the main factors attributed for the species decline are egg collection, disturbance in breeding colonies, drainage and agriculture conversion (BirdLife International 2012). The Bhitarkanika heronry is present inside the Park and is accorded the highest level of protection. Hence, the disturbances to the colonies due to direct anthropogenic impacts are nearly negligible. The reasons for the decline of the species in this colony despite good protection need further investigation.

Ali and Ripley (1968) reported that this bird lays around 2-4 eggs, however, in Bhitarkanika most of the clutches examined contained more than 4 eggs. In fact the clutch size was highest at 6 ±2.16 when compared with other species in

Table 4: Egg morphometry of Black-headed Ibis with other colonial nesters in Bhitarkanika heronry

Species	N	Mean egg length (mm)	Mean egg width (mm)	Mean egg mass (cm^3)
Asian Openbill	84	42.06 ±8.48	26.96 ±5.38	16.84 ±3.92
Large Egret	74	37.22± 8.17	24.91 ±5.82	13.01 ±4.44
Intermediate Egret	30	33.67± 2.31	22.77 ±1.83	9.00 ±1.90
Little Egret	19	30.58 ±2.57	20.58 ±1.17	6.59 ±0.60
Grey Heron	64	43.30 ±6.00	29.59 ±4.92	20.18 ±5.37
Purple Heron	51	40.33 ±6.37	25.96 ±4.52	14.66 ±4.49
Black-crowned Night-Heron	13	33.46 ±2.26	21.08 ±1.98	7.70 ±1.95
Black-headed Ibis	60	51.15 ±2.66	30.03 ±1.82	23.68 ±3.37
Little Cormorant	49	32.18 ±5.25	15.92 ±2.98	4.39 ±1.11
Darter	98	37.96 ±6.17	20.07 ±3.23	8.19 ±1.82

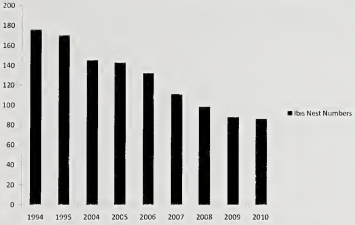

Fig. 6: Nesting trend of Black-headed Ibis in Bhitarkanika heronry

Source: 1994-1995 Dr. Bivash Pandav (pers. comm.), 2004-2006. This study and 2007-2010 – Mangrove Forest Division, Rajnagar, Odisha

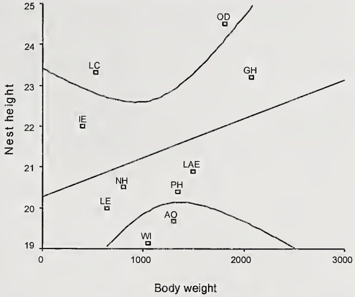

Fig. 7: Body mass vs. Nest height

the heronry. In spite of having the largest clutch size, hatching success was documented to be poor 15.74 ±21.43 (in %, n = 10) for this species in the colony and the exact reasons could not be ascertained. This poor success rate could also be a reason for their gradual decline in numbers.

Breeding biology: Black-headed Ibis builds platform nests and forms sub-colonies inside the heronry. The species built the nests quickly on arrival to the heronry and took just 5.50 ±0.71 days from nest initiation to clutch initiation. As mentioned earlier, the clutch size was highest for this species. The factors governing the clutch size have been of great academic interest in the discipline of evolutionary ecology in particular (Stearns 1976, 1992). The hypothesis proposed by Lack (1947, 1954, 1968) has garnered greater acceptance. Other workers suggest competition and environmental conditions to limit clutch sizes (Ashmole 1963; Cody 1966; Koenig 1984; Ricklefs 1980). Slagsvold (1982) suggests that predation or food supply for fledglings during the breeding season influences clutch size. Further empirical studies are required at Bhitarkanika heronry to determine the exact factors that govern the clutch size, which is larger than the previously reported studies.

The results of the Black-headed Ibis egg morphometry revealed that the average size of the eggs was 51.15 ±2.66 and 30.03 ±1.82 (n = 60), however, this result completely differed from that of Ali and Ripley (1968) who documented the egg size of Black-headed Ibis to be 63.5 x 43.1 (n = 150). This might be due to the fact that we had access to limited eggs and the sample size of Ali and Ripley (1968) was more than double of ours. The incubation period of the bird species in the heronry was 19.56 ±1.13 days; Ali and Ripley (1968) reported 23-25 days.

Table 5: Variability in nest initiation date and clutch initiation date across species in Bhitarkanika heronry

Species	n	Mean number of difference in days
Asian Openbill	20	30.53 ±8.50
Large Egret	30	9.19 ±3.50
Intermediate Egret	10	9.67 ±3.97
Little Egret	5	8.40 ±3.21
Grey Heron	20	10.17 ±11.62
Purple Heron	12	8.08 ±1.83
Black-crowned Night-Heron	5	5.20 ± .79
Black-headed Ibis	10	5.50 ±0.71
Little Cormorant	11	16.82 ±9.54
Darter	20	18.89 ±9.41

Table 6: Mean clutch size of Black-headed Ibis wrt other bird species breeding in Bhitarkanika heronry

Species	Clutch size
Black-headed Ibis	6 ±2.16
Darter	5.17 ±1.42
Little Cormorant	4.45 ±1.36
Asian Openbill	4.36 ±2.90
Purple Heron	4.25 ±1.86
Little Egret	3.8 ±1.09
Grey Heron	3.70 ±1.53
Intermediate Egret	3.33 ±1.80
Black-crowned Night-Heron	2.6 ±0.54
Large Egret	2.84 ±1.18

Table 7: Incubation duration of bird species nesting in Bhitarkanika heronry

Species	n	Mean number of days
Darter	49	28.55 ±8.86
Asian Openbill	38	26 ±2.84
Intermediate Egret	13	25.70 ±4.90
Large Egret	23	25.17 ±1.40
Purple Heron	30	24.73 ±3.27
Grey Heron	16	23.63 ±2.31
Black-crowned Night-Heron	12	23.25 ±0.96
Little Cormorant	15	22.10 ±2.23
Black-headed Ibis	23	19.56 ±1.13
Little Egret	14	18 ±3.06

The reproductive success was random, regardless of their spatial location at the heronry, disproving the well-proven hypothesis that breeding success may differ between centre and edge nests in colonial breeders. Many authors have documented that the peripheral/edge nesters suffer from higher predation in comparison to the centre nesters, as the centre nesters have more neighbours that defend probable predators as suggested in the 'selfish herd hypothesis' (Brown and Brown 1987; Kruuk 1964; Spear 1993; Wittenberger and Hunt 1985). Some authors have also suggested that the males preferred to establish their territories within the centre (Kittywake *Rissa tridactyla* – Coulson 1968; Least Tern – Burger 1988).

Space-use pattern: Black-headed Ibis was observed to nest away from most of the species within the heronry, forming sub-colonies on its own. The Ibis, though it arrives last in the heronry, tends to nest in the central location by displacing established nests of smaller birds like Great Egret, Intermediate Egret, and Little Egret. One other major factor to partition the space is by nest tree preference. The Black-headed Ibis, Asian Openbill, Little Cormorant, and Intermediate Egret showed a strong preference for nesting in *Excoecaria agallocha* trees.

Table 9: Comparison of hatching success Black-headed Ibis between central and edge nests

Nesting Variable	Mann-Whitney U	n	p-value
Clutch size	32.5	18	0.572
Clutch mass	23.0	18	0.172
Hatching success %	33.5	18	0.130
Fledgling success %	33.5	18	0.130

Correlation is significant at the 0.05 level (2-tailed)

Table 8: Variability in hatching success across species

Species	n	Hatching Success %
Purple Heron	12	57.74 ±36.62
Darter	20	50.22 ±37.91
Asian Openbill	20	45.24 ±38.64
Intermediate Egret	10	41.67 ±43.30
Little Egret	5	38.00 ±37.52
Large Egret	30	33.07 ±43.91
Little Cormorant	11	29.55 ±43.04
Grey Heron	20	22.22 ±40.12
Black-headed Ibis	10	15.74 ±21.43
Black-crowned Night-Heron	5	15.00 ±33.54

Certain studies have suggested that within homogenous vegetation, nesting birds partition the space by aligning their nests vertically in relation to their body length, i.e., the larger species nesting in the top and small species in the lower canopies. Some studies (Burger and Gochfeld 1990) did not validate this hypothesis, and the occupancy of a nest site is attributed mainly to the arrival times and the aggressive dominance of the larger species (Burger 1978, 1982). Our results on vertical alignment of nests did not support the body mass-nest height hypothesis, which postulates a direct positive correlation between body weight and nest height among colonial waterbirds.

CONCLUSION

This study attempted to establish a baseline information for Black-headed Ibis in Bhitarkanika heronry. Long term ecological studies are further required to investigate the probable causes for gradual population decline in this heronry, poor hatching and fledgling success. The probable threats that require immediate academic and conservation attention are the problems of excessive predation and toxic contaminants (organochlorine pesticides and heavy metals) found in the food web of this species. It is also critical to know about the entire life cycle of the species (during both breeding and non-breeding periods). Hence, studies to document their foraging areas, habitat use during non-breeding periods and mapping of

Table 10: Number of regurgitated boluses analysed

Species	Number of regurgitated boluses
Black-headed Ibis	31
All other nesting species	1,422

breeding colonies should be carried out, which will aid in identifying key areas for conserving this species and making informed conservation decisions.

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RESPONSE OF MIGRANT AND RESIDENT BIRD COMMUNITIES TO ANTHROPOGENIC DISTURBANCES IN SHIWALIK LANDSCAPE, UTTARAKHAND, INDIA

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Frequent compounded perturbations in terms of lopping, grazing, biological invasions, firewood and non-timber forest product (NTFP) collection gradually alters the habitat, and consequently dependent biotic communities. However, it is quite difficult to quantify these disturbances due to their high frequency, low intensity, and interaction among themselves. In order to quantify and investigate the impact of such disturbances on the habitat of resident and migrant birds, we carried out a study in the dry forest of Rajaji National Park in the Shiwalik landscape. Grazing and firewood collection emerged as the major disturbance in the study area, which decreased linearly from the edge to the interior of the forest. Disturbance altered the structural components of the vegetation; however, we did not find major changes in the vegetation composition. Canopy opening due to lopping disturbance facilitated the growth of *Lantana camara* in the study area. Ninety percent of the migrant bird community wintering in the study area belonged to the insectivorous guild. Out of 18 migrant species observed during the entire study period, 44% belonged to understorey-insectivores guild and 33% to canopy-insectivores. However, in terms of abundance 67% of the migrants pertained to the canopy-insectivores guild. Guild composition in resident birds was more varied with a total of 11 guilds, and trunk-bark feeder guild comprised the maximum number of species (20%). Species richness of both migrant and resident birds did not change much with any of the disturbance components. However, densities of resident birds increased with increased lopping and timber extraction in the study area during winter. Resident and migrant birds exhibited similar distribution patterns across different disturbance gradients indicating equivalent sensitivity to disturbances.

Key words: bird communities, Rajaji National Park, disturbances, heterospecific attraction

INTRODUCTION

Conservationists throughout the world are concerned about the declining number of migratory bird species (Calvert *et al.* 2009; Faaborg *et al.* 2010; Terborgh 1989; Wilcove and Wikelski 2008). It becomes difficult to determine the actual cause of migratory bird decline due to the variety of habitat use during different phases of life cycle (Faaborg *et al.* 2010). Habitat conditions in breeding, stopover and wintering sites are the key factors influencing survival and reproduction of migrants (Sherry and Holmes 1995). Research and management of migrant birds generally focuses on conditions in the breeding sites where they spend less time than their wintering sites. Protection and food resources in wintering areas ensure survival of individuals as well as nutrient build up for migrating back to the breeding grounds and possibly for future reproduction (Calvert *et al.* 2009). Some of the migratory birds spend more time in their wintering and stopover sites than their breeding sites. Therefore, habitat degradation in wintering sites could have detrimental effect for migratory birds (Terborgh 1989). During their stay in wintering sites, migrants interact and share resources with resident bird species. Due to their high abundance in secondary forest and degraded areas, migrants are assumed to be subordinate to resident bird species (Powell 1980; Rappole *et al.* 1983). However, Terborgh (1989) emphasised that migrants are not weedy opportunists in tropical forests, but an integral part of the overall bird community.

Rapid degradation of wintering areas of these species puts direct pressure on the survival and future reproduction of migrants. Subsistence use of forest by the communities residing in and around protected areas (PAs) is one of the major causes of the degradation of forests throughout the world. The situation is more alarming in developing countries like India where approximately 69% of the PAs are inhabited by local communities whose population was put at *c.* 4.5 million (Kothari *et al.* 1989). These communities depend on forest not only for their survival, but also for livelihood. Removal of vegetation biomass during these disturbances modifies the habitat structure and composition (Daniels *et al.* 1995; Kumar and Shahabuddin 2005; Murali *et al.* 1996; Sagar *et al.* 2003), which in turn has implications for the survival and reproductive fitness of the biotic communities (Shahabuddin and Kumar 2006). Information about distribution of migrants in different quality wintering habitats, in relation to resident species, is still lacking from tropical countries, including India.

In this study we first investigated the impact of extractive disturbances on vegetation structure and composition in the dry plain Sal forest of Rajaji National Park

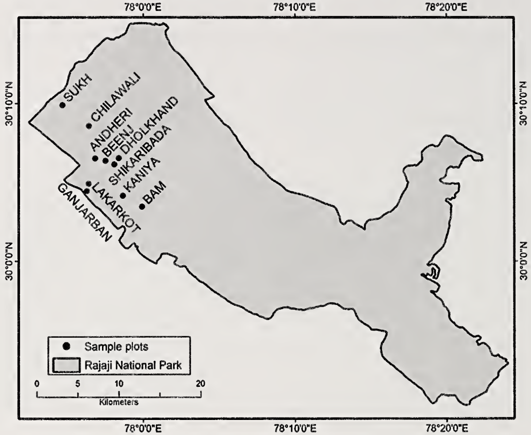

Fig. 1: Rajaji National Park, showing location of the sampling plots

and then examined the patterns of distribution of non-breeding winter migrants and resident bird species across different disturbance gradients. Finally we explored the relationship between resident and migrants across all the sampling plots to test how one community distributes itself in relation to others.

STUDY AREA

The study was conducted in Rajaji National Park (29°52' –30°15' N; 77°55'–78°5' E), one of the most important protected areas of India for the conservation of two charismatic mammal species, i.e. Tiger *Panthera tigris* and Asian Elephant *Elephas maximus*. Located in the north-western region of Shiwalik Hills of Uttarakhand state, Rajaji National Park (hereafter RNP) covers an area of 820 sq. km.

Intensive study sites were located in the dry plain Sal forest (5B/CI B) in the southern side of RNP (Champion and Seth 1968). This region is characterised by its serrated topography, with a number of steep ridges which emerge from the main Shiwalik ridge and have narrow valleys between them. Sal *Shorea robusta* forms the climax species of the forest succession and is the dominant species of this forest type. Most typical associates of Sal in this forest are *Terminalia tomentosa*, *Terminalia bellerica* and *Lagerstroemia parviflora* in the middle canopy. The understorey constitutes *Mallotus philippensis*, *Ehretia laevis*, *Cassia fistula*, *Miliusa velutina*, and *Holarrhena antidysenterica*. *Clerodendrum viscosum*, *Murraya koenigii*, *Colebrookea oppositifolia*, and *Adhatoda vasica* form the shrub layer. *Lantana camara* (hereafter lantana), an exotic invasive, occupies a large area in this forest type and forms dense thickets in disturbed areas.

This area has been home to a nomadic pastoral community – the Gujjars – for at least the last eight decades (Kumar 1995). Gujjars rely heavily on the forest for lopped fodder resources for their livestock to support their dairy product based economy, and for fuel and timber requirements. Till 2003, as much as 86% of the RNP was open to the Gujjar community for lopping and grazing. Indiscriminate lopping year after year resulted in tree mortality and weed infestation. In the past, Gujjars used to leave their dwellings in the landscape with the advent of summer around April for high altitude meadows in the Himalaya, where they would stay until October. However, now partly due to the fact that local communities in the Himalaya do not want to share their resources with the Gujjars and partly owing to socio-economic changes within the community itself, most of them have abandoned this traditional migration. The reduction in migration has resulted in their increased demands on the RNP landscape. However, a major relocation drive, started almost a decade back, of the Gujjar families from RNP to Haridwar

(Pathri and Gaindikahta resettlement colonies) helped in considerable release of pressure on the forest. As a result, some ranges have little to moderate disturbance by Gujjars, whereas others are completely undisturbed. Another major disturbance in this area is the collection of non-timber forest products (NTFP), including Bhabar grass *Eulaliopsis binata* (Dhaundiyal 1997). Bhabar grass contributes significantly to the subsistence economy of the large number of people living on the boundary of the dry plain forest. However, due to restrictions imposed under the Wildlife (Protection) Act, Bhabar grass collection was banned inside the Park. Therefore, the relocation of Gujjars, and stringent implementation of the law by forest officials, has created a gradient of disturbances in the study area.

The bird diversity of this region is even more remarkable, with 312 species of birds (Pandey *et al.* 1994). Of these, 144 are residents, 89 are migrants, 53 are altitudinal migrants, and the status of 18 is unknown.

METHODS

1. Site selection

To find out the relationship between disturbance, vegetation and bird communities sampling plots were chosen across a gradient of human disturbance through a preliminary survey in dry plain Sal forest (Fig. 1) of RNP. A total of 10 sampling sites were chosen across the entire landscape. At each site a 1 x 1 km representative area, which was reasonably homogenous, was delineated (grid) as sampling plot, leaving a buffer of at least 250 m from the boundary to negate 'edge effects'. Each plot again had three parallel line-transects at a distance of 250 m from the edge of the grid. On each transect three points were marked at a distance of 250 m (Fig. 2). At each point, nested circular plots were established for enumerating vegetation structure and composition, and anthropogenic disturbances. The same points were used to collect data on bird composition and abundance through the variable radius point transect method. A total of 89 points were used for data collection on vegetation disturbance and birds.

2. Vegetation Sampling

Around each intensive sampling point concentric 10 m and 5 m radius plots were laid to enumerate vegetation structure and compositional attributes for the tree and shrub layer respectively. In total, 89 vegetation plots (one plot had 8 intensive sampling points) were laid for both tree and shrub layer variables during two winter seasons (2010-2011). All woody vegetation GBH 20 cm or above was considered as trees. In each 10 m radius plot number, identity of species, GBH, canopy spread in two perpendicular diameters, and top and bottom height of canopy for each tree was recorded. Percent canopy cover was measured directly by means of a spherical densitometer, as the average of crown-cover readings taken from the centre of the plot in four cardinal directions.

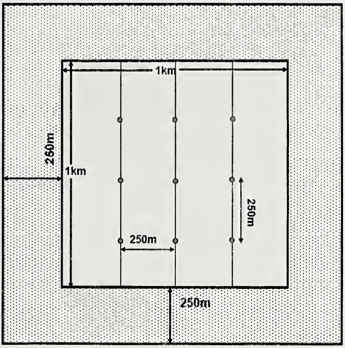

Fig. 2: Diagrammatic representation of the sampling plot. Each plot had an area of 1 sq. km with a buffer of 250 m on each side. Intensive sampling points were laid at a distance of 250 m from the edge of the plot (shown as points)

Shrub variables were measured in circular plots of 5 m radius nested in the tree plots mentioned above. All woody vegetation less than 20 cm GBH was considered as shrubs. In each shrub plot, species identity, number of individuals, height and canopy spread in two perpendicular diameters for each shrub was recorded.

3. Disturbance quantification

All the disturbance variables were quantified in the 20 m radius plot nested around the intensive sampling plot. Parameters used for quantification of disturbance were percentage of lopped trees (PERLOPP), lopping intensity on each tree (AVSCLOPP), number of dung pats (CATTDUNG), number of human trails passing through the plot (TRLN), percentage of grazing (GRZ), and number of cut trees (CUTTR) and cut stumps (CUTST). Intensity of lopping on each tree was estimated as an index. According to this index an intact tree with no sign of lopping gets zero value, a tree with less than half its branches lopped gets value 1, a tree with 50% lopped branches gets value 2, more than half of the branches lopped gets 3 and a tree with all branches lopped gets 4 (Shahabuddin and Kumar 2006).

4. Avifaunal sampling

Variable radius point transect method (Bibby 2000) was used to collect data on bird communities. All the points were at least 250 m apart from the centre of all the other points in the plot to avoid overlaps in bird encounters (Hansen *et al.* 1995). Birds were observed for 5 minutes at each point after an interval of 2 minutes from reaching the point (settling down time). It was observed that there were no substantial additional observations beyond the 5-minute period. Moreover, the chances of double counting get enhanced for longer periods. All birds seen or heard were recorded.

Additionally, the number of individuals and distance from the observer were also recorded. Distance was recorded using a laser rangefinder. All the birds were identified using standard field guides (Grimmett *et al.* 1999). All the point transects were conducted by a single observer (M. Kaushik) to avoid observer bias. Only the birds using the area during the count were recorded and all the birds that were transient were ignored.

Bird observations were made between 0.5 and 3 hrs after sunrise when visibility and bird activity is the highest (Raman *et al.* 1998). Only one plot comprising nine points was selected for bird sampling each day. All the points were visited for three mornings. To capture the maximum species variation during the study period, all the points were visited after a gap of at least seven days. Again, within a plot, the order of visiting the points was reversed each morning to negate the bias due to flushing of birds by the observer. Data of two winter seasons (2010-2011) was used for analysis.

STATISTICAL ANALYSIS

Principal component analysis (PCA) was carried out with the seven measured disturbance variables to extract the major disturbance regimes in the study area. All the disturbance variables were z-standardised (mean zero and unit standard deviation) before carrying out the PCA so that all variables got equal weight (Jongman *et al.* 1995; McGarigal *et al.* 2000). PCA was done using software SPSS (Version 16). Only those principal components with eigenvalue greater than one were selected. Pearson correlation was carried out between PCA scores of disturbance variables and vegetation variables (structural and compositional) to find out the relationship between them. Species richness and diversity were estimated for migrant and resident bird species through the point count data using software Pc-Ord version 4 (McCune and Mefford 1999). The density of resident and migrant birds was estimated using software Distance 5 (Thomas *et al.* 2010). Scatter plots in conjunction with generalised linear model (GLM) were used to investigate the response of both migrant and resident bird species to major disturbances in the study area. Distance of all the sampling plots was calculated using software ArcGIS. Correlation was done between different disturbance components and distance of sampling plots from the forest edge.

RESULTS

Disturbance variables were summarised using principal component analysis (PCA) and sampling plots were plotted on the first two disturbance components. Results of PCA extracted three major disturbance factors (i.e., grazing and fodder collection, lopping pressure and timber extraction), which explained 74% of the total variation in disturbance variables. Variation explained was 31%, 27%, and 16% by PC1, PC2, and PC3 respectively. Most of the variables positively contributed to the first principal component with the exception of variables related to timber extraction. The loadings for the second axis were low for the metrics related with livestock and firewood collection, but high for lopping disturbance (Table 1).

Segregation of sites using PCA corresponded closely with that made *a priori* by investigators. Of all the sampling plots, Lakarkot had the highest pressure due to grazing and firewood collection, followed by Andheri. Lopping pressure was highest in the Ganjarban and Sukh plots. Shikaribada showed lowest mean and variance for both disturbance gradients (Fig. 3).

Although all the disturbance components showed a declining trend with increased distance from the edge (grazing and fire wood collection: $r = -0.40$, $p = 0.25$; timber extraction: $r = 0.47$, $p = 0.16$), the trend was significant only for lopping pressure ($r = -0.85$, $p = 0.001$).

Table 1: Metric loadings for all three principal components extracted through Principal Component Analysis

	PC1	PC2	PC3
Grazing and Firewood collection			
TRLN	0.74	0.09	-0.04
CATTDUNG	0.64	0.05	0.47
CUTTR	0.76	-0.08	-0.12
GRZ	0.75	0.27	-0.01
Lopping pressure			
AVSCLOPP	0.07	0.95	0.03
PERLOPP	0.12	0.94	0.07
Timber extraction			
CUTST	-0.11	0.06	0.93

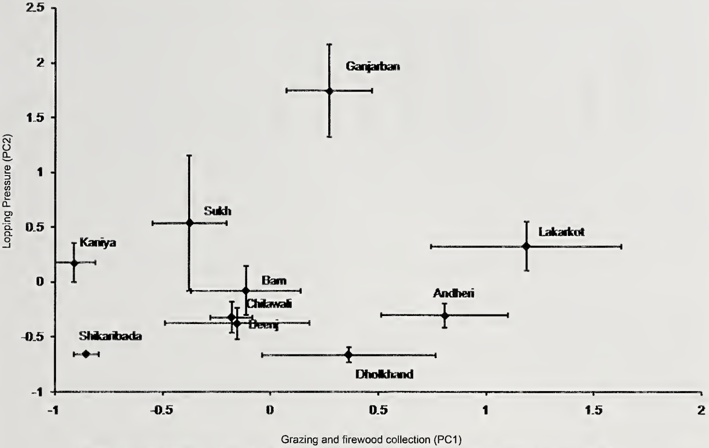

Fig. 3: Mean and standard error of two extractive disturbance components across different sampling plots

On correlating the vegetation variables (structural and compositional) we found that, percentage canopy cover was negatively related to grazing and firewood collection (PC1), whereas a strong positive relationship was observed between lopping pressure (PC2) and tree basal area. Interestingly, Lantana density also showed a significant positive relationship with lopping pressure. None of the vegetation attributes was found to be associated significantly with timber extraction (PC3). Both tree and shrub diversity did not show any significant relationship with any of the PCs (Table 2).

A total of 18 migrant and 66 resident bird species were detected within the study area across all the sampling plots over a two year period (Appendix 1). Richness of resident bird species was highest in the least disturbed plot of Shikaribada (41) and lowest in the moderately disturbed plot of Beenj (24). Highest richness of migrant birds was found in a moderately disturbed plot of Bam (13), and Beenj had the lowest migrant richness (4). Average density of migrants and resident birds for the study area was 2.9 ±0.08 (indi/ha) and 23.6 ±0.08 (indi/ha) respectively. Densities of both resident and migrant was highest in the disturbed plot Sukh (resident = 55.5 ±18.6, migrant = 22.9 ±20.6), and lowest in the moderately disturbed plot of Dholkhand (resident = 8.3 ±15.25, migrant = 3.3 ±20.4). The segregation of species in both the communities on the basis of their foraging guild revealed that resident birds had 11 guilds, whereas migrants belonged to only 6 guilds. Out of 18 migrant species observed during the entire study period, 44% belonged to understorey-insectivores guild and 33% to canopy-insectivores. Guild composition in resident birds was broader and trunk/bark feeder guild contributed the maximum number of species (20%) followed by understorey-insectivores (17%). However,

Table 2: Pearson's correlation between principal components of disturbance and vegetation (structural and compositional) variables

	Tree basal area (m^2)	Tree crown cover (m^2)	% canopy cover	Tree density	Shrub density	Shrub crown cover (m^2)	Lantana density	Shrub diversity	Tree diversity
PC1	0.17	-0.31	-0.65*	-0.19	0.40	-0.27	-0.09	0.29	0.04
PC2	0.81**	0.18	-0.29	0.27	-0.45	-0.01	0.67*	0.33	0.54
PC3	0.25	0.35	0.28	0.15	-0.20	0.11	0.27	-0.09	0.18

Statistically significant correlations between disturbance and vegetation variables are indicated with symbol* (*=p<0.05 and **=p<0.01)

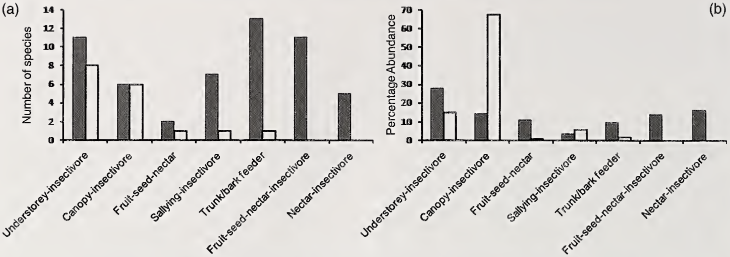

Fig. 4: Guild composition of resident and migrant bird species in terms of (a) species richness and (b) abundance

in terms of abundance, 67% of the migrants were canopy-insectivores and 14% were understorey-insectivores. Even in the resident bird community, 28% of the total abundance was contributed by understorey insectivores, followed by the canopy-insectivores (14%). For the graphical representation, we included guilds with more than 1% abundance (Fig. 4).

Both resident and migrant bird species richness showed declining trends with all the disturbance components, however, the results were not significant (Table 3). Densities of resident birds showed a declining but non-significant trend with grazing and firewood collection (PC1). A significant increasing trend was found between resident bird density and lopping disturbance (PC2), as well as timber extraction (PC3). Densities of migrant birds followed the same trend as resident birds, however, the relationship was only slightly significant for timber extraction (PC3, Fig. 5).

A positive correlation was found between the density estimate of migrant and resident species (r = 0.65, p = 0.04, Fig. 6a). Similarly a strong positive correlation was found between the resident and migrant species richness (r = 0.78, p=0.007) and diversity (r = 0.72, p=0.01, Fig. 6b).

DISCUSSION

Grazing and firewood collection were the major disturbance factors in the study area as they constituted the first principal component and explained the maximum variation in disturbance variables. Most of the different indicators used to quantify disturbance in this study were positively correlated with each other, which indicates concurrent nature of small-scale disturbances (Karanth *et al.* 2006; Martorell and Peters 2005; Singh 1998). Lopping pressure inside the Park depends largely on the availability of tree species preferred by Gujjars. However, areas preferred for lopping are not nececessarily subject to other disturbance activities. Therefore, lopping constituted a separate disturbance component.

In this landscape, disturbance intensities are influenced by flat terrain or accessibility, proximity to human habitation (Kurien *et al.* 2007) and degree of protection. In our study, we found that all disturbances declined as we moved deeper into the forest, which is coherent with other such studies (Karanth *et al.* 2006; Kurien *et al.* 2007; Thapa and Chapman 2010). Segregation of sampling plots across the first two principal

Table 3: Results of generalised linear model (GLM) for the resident migrant richness and density across different disturbance components

		Resident			Migrant		
Community attributes	Disturbance component	ß	SE	Z	ß	SE	Z
Richness	PC1	-0.003	0.09	-0.004	-0.01	0.17	-0.08
	PC2	-0.05	0.08	-0.65	-0.15	0.17	-0.90
	PC3	-0.27	0.18	-1.51	-0.56	0.35	-1.61
Density	PC1	-0.48	0.33	-1.4	-0.42	0.28	-1.50
	PC2	0.62	0.26	2.3*	0.43	0.25	1.72
	PC3	1.59	0.47	3.4*	1.01	0.51	1.95

Parameter estimate of the best model showing regression coefficient ±SE, z-statistics and significance (**= p= 0.001,*= p=0.01) components revealed that sampling plots such as Lakarkot and Ganjarban near the Park boundary suffered higher disturbance in terms of grazing, firewood collection, and lopping. In contrast, plots such as Shikaribada in the forested interior of the Park boundary experienced negligible disturbance.

Despite being cryptic, small extractive disturbances are known to bring severe changes in the habitat structure (Kumar and Shahabuddin 2005; Ramírez-Marcial *et al.* 2001; Sagar *et al.* 2003; Singh *et al.* 1997), which effects regeneration and stand composition (Beckage and Clark 2003). All vegetation structural variables did not show a strong relation with disturbance gradient, but a negative trend was evident for the foliage cover with first two disturbance components. Canopy opening and overgrazing lead to more sunlight reaching the forest floor and could decrease soil moisture and increase the temperature. Such overall increase in xeric conditions would be more detrimental for dry forest, as very few species would be able to cope with extremely high temperature and increased irradiance (Belnap 1995; Milton and Dean 1995; Valone *et al.* 2002). Enhanced understorey growth increases the fodder and firewood availability in open areas, therefore these areas showed higher disturbance due to grazing and firewood collection.

Canopy openings increase resource availability and also modify the microclimate, which is consistent with the disturbance patch invasion model (Gentle and Duggin 1997). According to this model, removal of competitive biomass and disruption of interspecific competitive interactions creates patches of increased resources. Many exotic weeds benefit from such disturbances and exert substantial pressure, including competition, on the native species (Fischer *et al.* 2006; Harper *et al.* 2005). In our study area, increased lopping pressure intensified Lantana density, supporting the disturbance patch invasion model. Such an increase in lantana cover will provide dense shade which would prevent establishment of herb and tree seedlings, eventually resulting in overall structural and compositional change in the forest (Sharma and Raghubanshi 2006).

Compared to migrants, residents showed a stronger relationship with disturbance variables. In addition, large scale disturbances such as timber extraction affected the resident bird richness more strongly than the small scale disturbances during winter. Insectivory appears to be the major foraging strategy during the winter, as the majority of migrants (90%) as well as the residents are insectivores. The majority of the resident birds appear to utilise the understorey vegetation layer

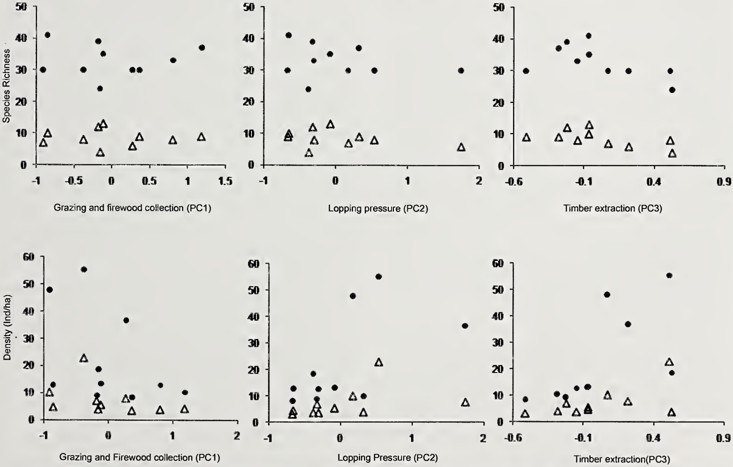

Fig. 5: Scatter plots between bird community parameters (richness and density) and extractive disturbance components. Resident bird community is represented by closed circles and migrant bird community by open triangles

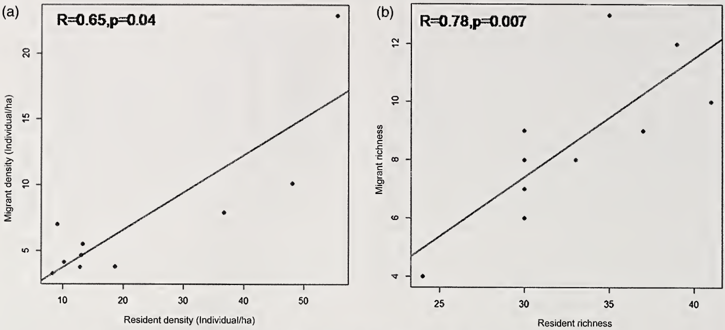

Fig. 6: Pearson Correlation between resident and migrant (a) density and (b) species richness

during the food-scarce winter season. This could be one of the mechanisms of accommodation of migrant birds during food shortage, as 67% of the migrant birds foraged in the canopy.

Past studies have suggested that migrants are more flexible than residents in their habitat use and are potentially more tolerant of disturbance (Greenberg 1995; Hutto 1989; Karr 1976). Yet there is evidence to prove that both migrants and residents share similar distribution pattern across habitat gradients (Emlen 1980; Petit *et al.* 1992). Smith *et al.* (2001) during their study in the Yucatan peninsula found that all stages of successional forest supported highly similar bird assemblages and did not differ in bird abundance or diversity. Moreover, residents and migrants distributed themselves similarly across successional gradients. Similarly, a study by Wallace *et al.* (1996) in the Cuban forest revealed that numbers of migrant and resident species were significantly positively correlated. Our study from Shiwalik landscape also follows a similar trend. Both species richness and density of migrant and resident birds were significantly positively correlated. This suggests that both resident and migrant birds might be equally tolerant or sensitive to disturbances.

Another possible explanation for the strong positive association between resident and migrant birds could be attraction between the two communities. Mönkkönen *et al.* (1990) hypothesized that migrants use resident birds as cues to profitable breeding sites and they called this phenomenon "heterospecific attraction". In experimental studies in boreal forests of North America and Europe, both richness and densities of migrants increased with increasing resident densities (Forsman *et al.* 1998; Mönkkönen *et al.* 1997). Similarly, a study conducted on resident Titmice and Pied Flycatcher in Finland showed that migrant flycatchers were attracted to the presence of Titmice and accrued benefits from this (Forsman *et al.* 2002). However, all studies on heterospecific attraction are conducted during the breeding season and there are no studies to verify this phenomenon in wintering sites. Still, it could be one of the most likely explanations for strong correlation between two bird communities. Such positive interaction between two potential competitors is suggested as highly beneficial for the migrants and neutral or beneficial for the residents (Forsman *et al.* 2002; Forsman *et al.* 2007; Mönkkönen and Forsman 2002). However, more studies on the interaction between resident and migrant birds in their wintering areas will strengthen our observation.

All these studies suggest that both migrant and resident bird species respond similarly to disturbance. These broad generalisations, however, should not be used for formulating conservation strategies for both groups. Different foraging guilds and individual species could vary significantly in their response to habitat disturbance, demanding specific conservation attention.

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Appendix 1: Bird species abundances recorded in 10 sampling plots in the dry forest of Rajaji National Park

Bird species	Sampling plots										Feeding Guild
Migrant Species	1	2	3	4	5	6	7	8	9	10	
Certhia himalayana	0	1	2	2	1	0	1	1	0	1	TBF
Anthus hodgsoni	8	5	0	0	0	0	0	39	9	0	GI
Phoenicurus coeruleocephala	0	0	0	3	0	0	0	0	0	0	UI
Saxicola ferreus	5	0	0	0	0	1	0	7	2	0	UI
Ficedula parva	4	2	0	8	3	0	1	8	0	0	UI
Ficedula strophiata	1	1	0	0	2	1	0	0	2	0	UI
Ficedula tricolor	0	4	0	2	0	5	0	0	2	3	UI
Phylloscopus fuscatus	0	2	0	0	0	0	0	0	0	1	UI
Seicercus whistleri	3	6	0	6	2	0	1	0	4	0	UI
Phylloscopus xanthoschistos	17	24	7	24	18	14	4	9	26	9	CI
Phylloscopus humei	24	30	15	30	27	6	16	24	35	27	CI
Phylloscopus chloronotus	1	0	0	8	3	0	1	2	0	0	CI
Phylloscopus tytleri	0	0	1	0	0	1	1	0	0	0	CI
Phylloscopus occipitalis	0	0	0	0	0	0	0	0	0	3	CI
Hypsipetes leucocephalus	0	0	0	3	0	0	0	0	0	0	GI
Culicicapa ceylonensis	0	6	0	6	4	0	0	1	8	11	SI
Sylvia curruca	0	4	0	3	0	0	0	5	1	0	CI
Zoothera dauma	0	0	0	0	0	1	0	0	0	0	UI
Resident species											
Spizaetus cirrhatus	0	0	0	0	0	0	0	3	5	0	R
Spilornis cheela	0	1	0	1	0	0	0	1	0	0	R
Accipiter nisus	0	0	0	0	0	1	0	0	0	0	R
Pernis ptilorhynchus	0	0	0	2	0	0	0	0	0	0	R
Accipiter badius	0	0	0	0	0	0	0	0	0	1	R
Aegithina tiphia	3	4	1	0	0	1	2	0	2	0	CI
Buceros bicornis	0	0	0	0	2	0	0	0	6	0	FI
Ocyceros birostris	0	0	0	2	0	1	0	2	0	0	FI
Anthracoceros albirostris	4	61	0	7	7	0	1	0	18	0	FI
Hemipus picatus	9	0	8	5	14	4	1	0	26	0	SI

Appendix 1: Bird species abundances recorded in 10 sampling plots in the dry forest of Rajaji National Park (*contd.*)

Bird species	Sampling plots										Feeding Guild
Migrant Species	1	2	3	4	5	6	7	8	9	10	
Coracina macei	0	0	0	0	0	0	2	1	4	0	CI
Pericrocotus flammeus	0	0	0	2	0	0	0	0	0	0	CI
Pericrocotus cinnamomeus	111	74	53	60	80	10	35	54	115	25	CI
Chloropsis aurifrons	0	2	0	0	0	0	0	0	0	0	CI
Orthotomus sutorius	7	10	2	3	0	2	2	6	3	1	UI
Prinia hodgsonii	182	64	59	98	62	21	64	157	50	32	UI
Chalcophaps indica	0	0	0	1	0	0	0	0	0	0	G
Corvus macrorhynchos	5	7	0	6	0	4	7	4	10	11	O
Urocissa erythrorhyncha	0	0	0	0	1	0	0	1	1	0	O
Dendrocitta vagabunda	4	12	7	18	3	3	4	15	16	14	O
Dicaeum erythrorhynchos	0	1	0	0	0	0	0	0	0	0	NI
Dicaeum agile	2	0	0	6	2	0	1	0	1	0	NI
Dicrurus macrocercus	0	0	0	0	0	0	0	2	0	0	SI
Dicrurus hottentottus	0	0	0	0	0	0	1	3	0	0	FSNI
Dicrurus caerulescens	7	3	3	8	3	1	3	0	5	12	SI
Halcyon smyrnensis	0	0	0	0	0	0	0	1	0	0	SI
Megalaima zeylanica	0	0	0	0	0	0	0	0	0	1	FI
Megalaima haemacephala	1	1	0	3	0	0	0	0	7	0	FSNI
Megalaima lineata	0	15	0	2	5	0	1	1	4	0	FI
Nyctyornis athertoni	0	2	0	1	0	0	0	0	0	0	SI
Saxicola caprata	0	0	0	0	0	1	0	0	0	0	UI
Cyornis tickelliae	1	9	0	0	0	1	1	3	2	2	SI
Copsychus malabaricus	1	0	0	2	0	0	0	0	0	0	UI
Aethopyga siparaja	1	3	0	2	4	2	0	2	4	0	NI
Nectarinia asiatica	0	0	0	2	0	0	0	0	0	1	NI
Oriolus xanthornus	1	9	2	7	7	14	8	5	6	7	FI
Parus major	41	27	18	32	59	11	17	25	27	17	TBF
Pavo cristatus	0	7	0	0	0	0	0	5	0	0	O
Lophura leucomelanos	0	0	0	0	0	0	0	0	2	0	UI
Gallus gallus	1	25	3	1	0	10	0	0	1	2	UI
Dinopium benghalense	5	3	1	5	2	1	4	3	5	1	TBF
Dendrocopos macei	3	3	0	9	1	3	3	2	6	2	TBF
Chrysocolaptes lucidus	0	0	1	6	4	0	0	5	1	1	TBF
Dendrocopos canicapillus	8	4	6	5	6	1	4	8	2	4	TBF
Picus canus	0	0	0	0	0	0	0	0	1	0	TBF
Dinopium shorii	0	0	1	2	0	0	0	0	0	1	TBF
Micropternus brachyurus	0	0	0	2	0	0	0	0	0	0	TBF
Picus sqamatus	0	0	0	0	1	0	0	0	0	0	TBF
Picus xanthopygaeus	2	0	0	1	0	0	1	1	0	0	TBF
Chrysocolaptes festivus	0	0	1	0	4	0	0	0	0	0	TBF
Psittacula cyanocephala	12	20	1	0	4	6	0	6	6	4	G
Psittacula krameri	68	50	77	43	32	30	68	78	23	3	FSN
Pycnonotus leucogenys	13	72	12	0	4	62	35	21	9	0	FSNI
Pycnonotus cafer	0	54	0	0	10	53	8	8	77	4	FSNI
Riphidura albicollis	5	4	0	4	2	0	1	1	4	7	SI
Sitta cinnamoventris	4	0	8	6	8	1	1	1	8	4	TBF
Sitta frontalis	0	0	3	1	1	0	1	0	3	0	TBF
Glaucidium radiatum	2	1	0	1	0	0	0	0	1	1	R
Acridotheres tristis	2	0	0	0	0	0	0	4	0	0	FSNI
Chrysomma sinense	0	0	0	0	0	10	0	0	0	0	UI
Tephrodornis pondicerianus	6	7	1	5	4	3	2	7	12	2	CI
Stachyris pyrrhops	2	9	0	0	0	4	0	4	4	12	UI
Turdoides striata	40	36	26	21	12	23	78	93	26	55	UI
Pellorneum ruficeps	0	2	0	0	0	0	0	0	0	0	UI

Appendix 1: Bird species abundances recorded in 10 sampling plots in the dry forest of Rajaji National Park (*contd.*)

Bird species	Sampling plots										Feeding Guild
Migrant Species	1	2	3	4	5	6	7	8	9	10	
Pomatorhinus erythrogenys	0	8	0	0	0	0	0	2	7	0	UI
Zosterops palpebrosus	88	274	15	62	89	9	44	22	66	87	NI

Sampling Plots: 1=Andheri, 2=Bam, 3=Beenj, 4=Chilawali, 5=Dholkhand, 6=Ganjarban, 7=Kaniya, 8=Lakarkot, 9=Shikaribada, 10=Sukh. Abbreviations used for Feeding guild: TBF=Trunk/bark feeder, GI=Ground insectivore, UI=Understorey insectivore, CI=Canopy insectivore, FI=Fruit insectivore, FSNI=Fruit seed nectar insectivore, FSN=Fruit seed nectarivore, SI=Sallying insectivore, NI=Nectar insectivore, O=Omnivore, R=Raptor

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IDENTIFYING IMPORTANT AREAS FOR BIRD CONSERVATION IN THE WESTERN GHATS REGION OF MAHARASHTRA, INDIA

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Despite holding vital habitats and biodiversity that call for conservation measures, the Western Ghats region in Maharashtra are facing severe threats due to loss of forested area. We carried out a survey of birds of this area from 2007 to 2009 to enumerate species richness and assess the distributional status of birds of the region, with focus on eight endemic bird species in seven Protected Areas (PAs) and 11 Reserve Forests (RFs) to identify the areas that are important for long-term conservation of birds in the region. Bird species richness was highest in the PAs of Chandoli and Phansad and in the RFs of Sawantwadi, Lonavala, and Amba. The number of endemic species was highest in the protected areas of Chandoli, Koyna, and Radhanagari, and in the reserve forests of Lonavala, Chandgad, Sawantwadi, Amba, and Amboli. Prioritisation of areas was done based on bird species richness, presence of endemic and threatened birds, and threat levels. Based on the results of the survey, we suggest declaration of Chandoli National Park and Sawantwadi as Important Bird Areas (IBAs) and Sawantwadi, Lonavala, Amba, Amboli, and Chandgad for inclusion under Environmentally Sensitive Area, as unregulated commercial development is emerging as a major threat to these regions.

Key words: Maharashtra, Western Ghats, endemic birds, forest degradation, biotic pressure, bird protection

INTRODUCTION

The Western Ghats region in India has been listed as one of the 34 Global Biodiversity Hotspots owing to its extraordinarily rich biodiversity (Myers 1990). The Western Ghats occupy 7% of India's land mass, of which only one-third is under forest cover and yet it supports 30% of the country's biodiversity, which makes it one of the high priority regions for conservation. Broadly, the Western Ghats are divided into two main regions: the northern Western Ghats, which lie in Gujarat, Maharashtra, Goa, and the northern districts of Karnataka, and the southern Western Ghats, which lie mainly in southern Karnataka, Tamil Nadu, and Kerala (Western Ghats Ecosystem Profile 2007).

Historically, the forests of Western Ghats were well-protected by local rulers and their inaccessibility prevented the people from cultivation and construction. By the 1890s, the forest administration was under British control and they introduced the system of reserving good quality forests, but soon began exploiting the timber for ship building and railways during the two World Wars. This exploitation continued in the post-independence era, leading to further fragmentation of forests in the Western Ghats (BVIEER 2010; Daniels *et al.* 1990). In recent times, land use changes due to urbanisation, industrial and agricultural expansion, mining, road building, and hydroelectric projects have further intensified habitat loss in the Western Ghats. There has been a decrease of 610 sq. km (10.57%) in dense forest cover and an increase of 346.9 sq. km (8.91%) in open forest cover from 1985–87 to 2005 (Panigrahy *et al.* 2010).

There are 58 Protected Areas (PAs) within the Western Ghats, and most of them are surrounded by human habitation. With a high density of 250 people/sq. km, anthropogenic pressures are escalating in the PAs and Reserve Forests (RFs). Recent analysis of threats in the Western Ghats region revealed that 90% of the PAs were facing local pressures, such as fuel wood collection, fodder removal and hunting; while landscape level pressures, such as mining, railways, and road building were relatively lower (Western Ghats Ecosystem Profile 2007).

Five hundred and twenty-eight bird species are recorded from the Western Ghats (Islam and Rahmani 2004). Of these 16 species are included in the Red Data List by the IUCN (BirdLife International 2010). To protect these birds and their ecosystems, Birdlife International has categorised regions having conservation-dependent endemic bird species as Endemic Bird Areas (EBAs). According to these criteria, Western Ghats is one of the important EBAs (Islam and Rahmani 2004; Stattersfield *et al.* 1998). While a few quantitative research studies on birds of southern Western Ghats exist (Daniels 1989; Daniels *et al.* 1990; Davidson 1889; Mudappa and Raman 2009; Raman 2001, 2006; Sidhu *et al.* 2010), the birds of the Western Ghats region of Maharashtra have been documented largely as descriptive natural history accounts (Betham 1902; Butler 1884; Fairbank 1876), in field guides (Pandey *et al.* 2003) or in sporadic observations (Abdulali 1965, 1981; Ali 1949, 1952; Ambedkar 1991;

Borges 1986; Monga and Rane 1986). The most comprehensive work has been done by Gole (1998) from 1994 to 1996, wherein he documented the presence of forest birds, including the endemics in the study area. More recently, Mudappa and Raman (2009) carried out an extensive survey on hornbills in the entire Western Ghats, including Maharashtra, with information on the presence of endemic birds of the region. However, a comprehensive field-based assessment of endemic birds from PAs and RFs of Western Ghats region of Maharashtra is absent. Such an assessment will help to designate areas that are valuable for bird conservation. The assessment is essential, given the rapid industrial and other developments that the Western Ghats region of Maharashtra currently face (BVIEER 2010; Panigrahy *et al.* 2010). Through this survey, we specifically seek to determine: a) areas that support endemic birds, b) major threats to the forests in this region, and c) areas important for long-term bird conservation.

Profile of Western Ghats region of Maharashtra

The Western Ghats region of Maharashtra extend from 15° 30' to 29° 30' N, and 72° 30' to 75° E in Western Maharashtra. They cover three distinct geographical regions. The Ghats region consists of mountain tops to the east of the Western Ghats crestline, ranging from 900 to 1,600 m above msl. Konkan is the western low-lying coastal region up to 400 m above msl. Mawal is the easternmost portion of the Ghats at 600 to 800 m above msl (Ghate 1993), and is the transition zone from the hills to the plains. From north to south there is a slight increase in rainfall. The Ghats region receives about 5,000 to 7,000 mm rainfall, whereas Konkan and Mawal record an average rainfall between 2,000 to 5,000 mm (Ghate *et al.* 1994). The Ghats region supports primarily evergreen forests. The region south of 19° N supports semi-evergreen forests, while the region to its north supports mainly deciduous forests. However, a few pristine pockets of evergreen forests still exist in Sawantwadi (16° N) and Phansad Sanctuary (18° N). At most places in the Western Ghats region of Maharashtra, evergreen forests exist as secondary forests mainly in the Ghats region, while in the foothills they are mostly semi-evergreen (Ghate *et al.* 1994). The surveyed sites are listed in Tables 1 and 2 and their locations are shown in Fig. 1.

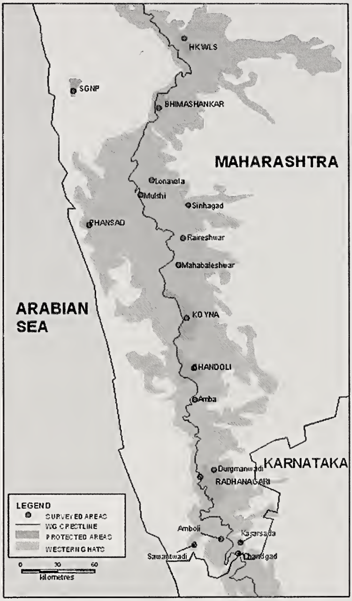

Fig. 1: Location Map of Surveyed Areas in Western Ghats of Maharashtra.
SGNP = Sanjay Gandhi National Park;
HKWLS = Harishchandragad-Kalsubai Wildlife Sanctuary

Of the 16 endemic birds of the Western Ghats, eight species are confined to southern Western Ghats, while the remaining eight species are found in the entire length of the Western Ghats. These species are the Crimson-backed Sunbird *Leptocoma minima*, Malabar Parakeet *Psittacula columboides*, Malabar Grey Hornbill *Ocyceros griseus*, White-bellied Blue Flycatcher *Cyornis pallipes*, Indian Rufous Babbler *Turdoides subrufus*, White-cheeked Barbet *Megalaima viridis*, Malabar Lark *Galerida malabarica*, and Nilgiri Woodpigeon *Columba elphinstonii*. In addition, the area also supports other important species such as the Great Pied Hornbill *Buceros bicornis*, Malabar Pied Hornbill *Anthracoceros coronatus*, Yellow-browed Bulbul *Iole indica*, Painted Bush-quail *Perdicula erythrorhyncha*, Malabar Trogon *Harpactes fasciatus*, Malabar Whistling-thrush *Myophonus horsfieldii*, and White-browed Bulbul *Pycnonotus luteolus* (Gole 1998; Islam and Rahmani 2004). Isolated records of the Black-headed Babbler *Rhopocichla atriceps* from Koyna (by Shantaram as mentioned *in* Gole 1998) and Black Baza *Aviceda leuphotes* from Bhimashankar (Rane and Borges 1987) have been reported.

Table 1: Details of Protected Areas (PAs) surveyed

District	Name of PA	Location	Altitude (m above msl)	Vegetation Type
Ahmednagar	Harishchandragad-Kalsubai WLS	19° 42' N, 73° 52' E	600–1,460	Moist deciduous, Semi-evergreen
Thane	Sanjay Gandhi National Park*	19° 18' N, 72° 57' E	up to 500	Moist deciduous, Semi-evergreen
Pune	Bhimashankar Sanctuary	19° 2' N, 73° 35' E	600–1,100	Moist deciduous, Semi-evergreen, Evergreen
Raigad	Phansad Sanctuary	18° 20' N, 72° 54' E	up to 500	Dry deciduous, Moist deciduous, Semi-evergreen
Sangli/Kolhapur	Chandoli National Park	17° 29' N, 73° 55' E	580–1,044	Semi-evergreen, Evergreen
Satara	Koyna Sanctuary	17° 38' N, 73° 45' E	500–1,100	Semi-evergreen, Evergreen
Kolhapur	Radhanagari Sanctuary	16° 22' N, 74° E	500–972	Semi-evergreen, Evergreen

*Tungareshwar Wildlife Sanctuary has been included in SGNP

Methodology

There are twelve districts in the Western Ghats of Maharashtra. The survey was carried out in eight districts in seven PAs and eleven RFs from 2007 to 2009. Since the study was designed as a multi-species avifaunal survey, we found the species richness measures to be most appropriate as it can generate an index of abundance of species as well as bird composition in an area. We used the MacKinnon's list method (MacKinnon and Phillips 1993) for the survey. This method is useful when the area to be surveyed is large and time period is short. It is also useful for comparing areas when the survey is conducted by multiple observers with different bird spotting and identification ability (Javed and Kaul 2002; O'Dea *et al.* 2004). MacKinnon's list method is a specific form of listing that records species on fixed-length lists rather than fixed-time lists. Thus, the area to be surveyed is sampled till first *n* species are encountered, where *n* is a fixed number (typically 10, 12, 15, or 20). The second list is started after completion of the first list and has the same fixed length. This process is repeated till the survey for an area is completed. The measure of effort is the number of lists. The length of a list is decided after a preliminary survey. Longer list size is selected in species-rich areas and shorter list size is selected in species-poor areas. Encounter of a species is recorded only once in a list even if it occurs multiple times. A repeat encounter in the same list does not add to number of species but to number of individuals encountered in the list. Commonly encountered species appear on multiple lists, while less common species appear in fewer lists. The number of individuals encountered can be recorded as a measure of the abundance of a species. To compare species richness between sites, cumulative numbers of species discovered are recorded over successive lists. Sites with higher species-discovery rates have higher richness than those with lower species-discovery rates.

We carried out preliminary trials whereby we concluded that a list of 12 species can be completed in a reasonably short period of time and a full day's survey can yield about 6 to 8 lists. On this basis we selected 12 bird species as the length of one list for this survey. In most sites we spent 2 to 4 days to survey different habitats for recording bird species. Each site was surveyed once during the same season. The survey being in a large geographic area, seasonal visits were not possible.The following information was recorded for each list: latitude and longitude, altitude, length of the trail, species and number of birds seen. Additionally, habitat parameters such as forest type, terrain, dominant trees and shrubs of the area, and average tree height were also noted.

To assess the status of endemic and other important birds, encounter rates were generated by calculating number of detections of endemic and important species per kilometre

Table 2: Details of Reserve Forests (RFs) surveyed

District	Name of RF	Location	Altitude (m above msl)	Vegetation Type
Pune	Mulshi	18° 44' N, 73° 40' E	600	Semi-evergreen
	Raireshwar	18° 25' N, 73° 53' E	700–1,350	Semi-evergreen, Grassland
	Lonavala & INS Shivaji	18° 46' N, 73° 24' E	up to 1,100	Moist deciduous, Semi-evergreen, Evergreen
	Sinhagad	18° 37' N, 73° 77' E	600–800	Moist deciduous
Satara	Mahabaleshwar	17° 52' N, 73° 39' E	1200–1,400	Semi-evergreen
Kolhapur	Amba	16° 58' N, 73° 47' E	1200–1,400	Semi-evergreen, Evergreen
Sindhudurg	Amboli	15° 57' N, 73° 59' E	700–800	Semi-evergreen, Evergreen
	Sawantwadi	15° 54' N, 73° 48' E	50–200	Semi-evergreen, evergreen, Moist deciduous
Kolhapur	Chandgad	15° 50' N, 74° 8' E	up to 500	Semi-evergreen
	Kasarsada	15° 55' N, 74° 16' E	1,000	Semi-evergreen
	Durgmanwadi	16° 45' N, 73° 9' E	500–980	Semi-evergreen

Table 3: Encounter rate of endemic birds in Protected Areas

Endemic Species	HKWLS	SGNP	Bhimashankar	Phansad	Koyna	Chandoli	Radhanagari
Crimson-backed Sunbird	0.4 (±0.12)	0.08 (±0.08)	0.25 (±0.07)	0.03 (±0.03)	0.86 (±0.16)	0.62 (±0.35)	0.33 (±0.09)
Malabar Grey Hornbill	-	-	-	0.03 (±0.03)	0.05 (±0.05)	0.19 (±0.19)	-
Malabar Parakeet	-	-	-	-	0.12 (±0.11)	0.09 (±0.09)	-
Malabar Lark	0.25 (±0.11)	-	0.04 (±0.04)	-	0.07 (±0.05)	0.19 (±0.12)	-
Nilgiri Woodpigeon	-	-	0.04 (±0.04)	0.03 (±0.03)	0.06 (±0.06)	0.09 (±0.09)	-
Indian Rufous Babbler	-	-	-	-	-	-	-
White-cheeked Barbet	0.04 (±0.02)	-	-	-	0.13 (±0.09)	0.23 (±0.15)	-
White-bellied Blue Flycatcher	0.11 (±0.09)	-	0.07 (±0.03)	-	0.19 (±0.08)	0.09 (±0.09)	-

HKWLS = Harishchandragad-Kalsubai Wildlife Sanctuary, SGNP = Sanjay Gandhi National Park
Figures in parentheses indicate standard error

travelled in the surveyed sites. To compare the relative abundance of an endemic species, we compared the encounter rate of the same species across the sites. An assessment of impact of anthropogenic pressures on the birds was carried out in four broad categories, namely presence of development projects in the area (windmills, mines, roads, railway, dams), anthropogenic pressure from local communities (encroachment on forest land, collection of firewood for commercial sale, lopping, livestock grazing), tourism, and hunting (hunting for meat or trade). This information was collected for each site by holding discussions with local people and forest staff, and by field observations. The severity of threat in each category was recorded as low, medium, or high, based on subjective assessment of the observer.

RESULTS

New Records

Our survey yielded two new records of birds from the Western Ghats of Maharashtra. The Grey-headed Fish-Eagle *Ichthyophaga ichthyaetus* (Horsfield 1821) was recorded near Chandoli Reservoir (17° 29' N; 73° 55' E). In Maharashtra, this species has been recorded from Tadoba Tiger Reserve (Naoroji 2006) but there is no published record from Western Maharashtra. The other new record was that of the Black-crested Bulbul *Pycnonotus melanicterus gularis*. Two individuals were seen in semi-evergreen forests surrounding a cliff at 629 m above msl near Amba Reserve Forest (16° 94' N; 74° E). Three more individuals were seen at Talkat Reserve Forest (15° 48' N; 73° 57' E) near evergreen forests along the roadside at 128 m above msl. The crestless race *P. m. gularis* of the Western Ghats has earlier been recorded from Goa southwards till Kerala and Tamil Nadu (Ali and Ripley 1987; Grimmett *et al.* 1999; Rasmussen and Anderton 2005).

Bird Species Richness

A total of 224 bird species from 48 families were identified during the survey. Species richness curves were plotted for PAs and RFs and are given in Figs 2 and 3 respectively. Since different sites have a different number of lists, only the first 10 lists were plotted for all the sites. Since the random nature of species discovery can make comparisons difficult, the data was first smoothened by carrying out 100 randomisations before plotting. The randomisation process yields fractional numbers of species which were rounded off to the nearest integer. The sites with highest species-discovery rates have the highest species richness and those with lowest discovery rates have the lowest richness. Among PAs, Chandoli and Phansad have the highest richness, followed by Sanjay Gandhi National Park (SGNP), Bhimashankar and Koyna. Harishchandragad-Kalsubai Wildlife Sanctuary (HKWLS) has the lowest species richness, which was expected, as the northern sites are generally thought to have lower richness and also because the forests of HKWLS

Table 4: Encounter rates of other important species in Protected Areas

Species	HKWLS	SGNP	Bhimashankar	Phansad	Koyna	Chandoli	Radhanagari
Great Pied Hornbill	-	-	-	-	-	-	-
Malabar Pied Hornbill	-	-	-	0.09 (±0.09)	-	0.08 (±0.08)	-
Yellow-browed Bulbul	0.09 (±0.08)	-	0.12 (±0.06)	-	0.67 (±0.14)	-	0.22 (±0.08)
Malabar Whistling-thrush	-	-	0.01 (±0.01)	-	-	-	-

HKWLS = Harishchandragad-Kalsubai Wildlife Sanctuary, SGNP = Sanjay Gandhi National Park
Figures in parentheses indicate standard error

Table 5: Encounter rate of endemic birds in Reserve Forests

Endemic Species	L'vla	M'shi	M'war	R'war	C'gad	S'gad	DMW	KSD	Amba	Amboli	S'wadi
Crimson-backed Sunbird	0.05 (±0.06)	0.57 (±0.25)	-	0.13 (±0.15)	-	-	0.36 (±0.05)	0.91 (±0.06)	0.21 (±0.21)	0.92 (±0.26)	-
Malabar Grey Hornbill	-	-	-	-	0.11 (±0.19)	-	-	-	0.12 (±0.12)	0.12 (±0.21)	1.09 (±0.77)
Malabar Parakeet	-	-	-	-	-	-	-	-	-	-	-
Nilgiri Woodpigeon		-	-	-	0.27 (±0.17)	-	-	-	-	0.60 (±0.38)	-
Malabar Lark	0.10 (±0.07)	-	0.2 (±0.12)	0.17 (±0.12)	-	-	0.51 (±0.10)	-	-	-	-
Indian Rufous Babbler	-	-	-	-	-	-	-	0.01 (±0.01)	-	-	-
White-bellied Blue Flycatcher	-	0.12 (±0.24)	0.06 (±0.18)	-	0.16 (±0.19)	0.50 (±0.00)	-	0.23 (±0.26)	0.14 (±0.14)	-	0.35 (±0.25)
White-cheeked Barbet	0.14 (±0.10)	0.13 (±0.13)	0.06 (±0.06)	-	-	-	-	0.28 (±0.22)	0.33 (±0.24)	0.48 (±0.38)	-

L'vla = Lonavala, M'shi = Mulshi, M'war = Mahabaleshwar, R'war = Raireshwar, DMW = Durgmanwadi, KSD = Kasarsada, C'gad = Chandgad, S'gad = Sinhagad, S'wadi = Sawantwadi. Figures in parentheses indicate standard error

Table 6: Encounter rates of other important species in Reserve Forests

Species	L'vla	M'shi	M'war	R'war	C'gad	S'gad	DMW	KSD	Amba	Amboli	S'wadi
Great Pied Hornbill	-	-	-	-	0.21 (±0.26)	-	-	-	0.22 (±0.15)	-	0.61 (±0.43)
Malabar Pied Hornbill	-	-	-	-	0.08 (±0.27)	-	-	-	-	-	-
Yellow-browed Bulbul	-	0.53 (±0.39)	-	-	0.64 (±0.22)	0.12 (±0.69)	0.15 (±0.15)	0.69 (±0.27)	0.14 (±0.12)	0.80 (±0.31)	0.05 (±0.04)
Malabar Whistling-thrush	-	-	0.06 (±0.06)	-	0.10 (±0.13)	-	-	-	0.14 (±0.14)	0.08 (±0.09)	-

L'vla = Lonavala, M'shi = Mulshi, M'war = Mahabaleshwar, R'war = Raireshwar, DMW = Durgmanwadi, KSD = Kasarsada, C'gad = Chandgad, S'gad = Sinhagad, S'wadi = Sawantwadi. Figures in parentheses indicate standard error

Table 7: Total (endemic and other important) bird species recorded from Protected Areas

Species	HKWLS	SGNP	Bhimashankar	Phansad	Koyna	Chandoli	R'nagari
Endemic	4	2	4	3	7	8	7
Others	1	-	2	1	3	3	3
Total	5	2	6	4	10	11	10

HKWLS = Harishchandragad-Kalsubai Wildlife Sanctuary, SGNP = Sanjay Gandhi National Park, R'nagari = Radhanagari

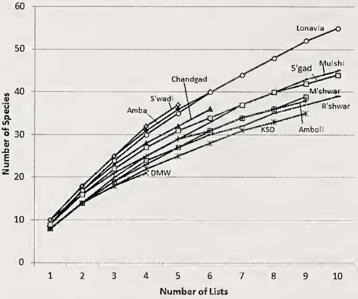

Fig. 2: Species richness curves for Protected Areas

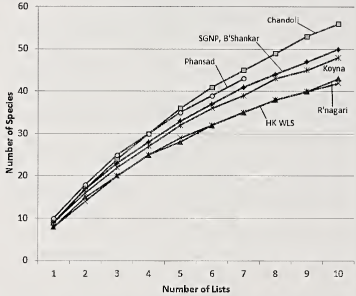

Fig. 3: Species richness curves for Reserve Forests

are highly fragmented. The low richness of Radhanagari is probably an anomalous result, which is explained in a section below.

Among RFs, Sawantwadi, Lonavala, and Amba have the highest richness. Chandgad, Sinhagad, and Mulshi have intermediate richness. The high altitude plateaux Mahabaleshwar and Raireshwar have low richness. Small sites such as Durgmanwadi (DMW) and Kasarsada (KSD) have very low richness. The high richness of Lonavala is unexpected because it is a northern site lacking in endemic species. A possible explanation for this is a varied habitat due to presence of deep valleys.

Encounter Rate of Endemic and other Important Bird Species

Among the endemic species, the Crimson-backed Sunbird was most widely distributed around edges, secondary forests, and plantations. The White-bellied Blue Flycatcher, a forest-dependent species, was encountered frequently along streams, waterholes, and riparian areas from many PAs and RFs. The Malabar Grey Hornbill was recorded from undisturbed semi-evergreen forests of PAs and RFs that were south of 16° N. We saw large flocks of Malabar Parakeet only in the PAs Radhanagari, Koyna, and Chandoli. There is a report of this species from INS Shivaji in Lonavala (Islam

Table 8: Total (endemic and other important) bird species recorded from Reserve Forests

Species	L'vla	M'shi	M'war	R'war	C'gad	S'gad	DMW	KSD	Amba	Amboli	S'wadi
Endemic	8	3	3	2	3	1	2	4	4	4	3
Others	3	2	2	-	4	-	1	1	3	3	3
Total	11	5	5	2	7	1	3	5	7	7	6

L'vla = Lonavala, M'shi = Mulshi, M'war = Mahabaleshwar, R'war = Raireshwar, DMW = Durgmanwadi, KSD = Kasarsada, C'gad = Chandgad, S'gad = Sinhagad, S'wadi = Sawantwadi

Table 9: Threat scores in Protected Areas

Sites	Development Projects	Encroachment	Biotic Pressure	Tourism	Poaching Hunting
SGNP	Medium	High	Medium	High	Medium
H'gad	High	-	High	High	High
Bhimashankar	High	Medium	High	Very High	High
Phansad	-	-	Medium	Low	Low
Koyna	Low	-	Low	Low	Low
Chandoli	Low	-	Low	Low	Low
Radhanagari	Medium	-	Medium	Low	Low

'-' indicates not observed or reported; SGNP=Sanjay Gandhi National Park; H'gad=Harishchandragad

and Rahmani 2004). The Nilgiri Woodpigeon, the only Vulnerable endemic of this region, was recorded in thickly wooded habitats and undisturbed riparian habitats of PAs. There are very few records of the Indian Rufous Babbler from the Western Ghats region of Maharashtra. It inhabits the understorey of moderately thick forests and secondary forest areas. We recorded the species from Kasarsada RF (Table 5).

The Great Pied Hornbill and Malabar Pied Hornbill are in the Near Threatened category and Schedule I species of the Wildlife (Protection) Act, 1972. We encountered both species from private forests and RFs of Chandgad, Amboli and Sawantwadi. The Malabar Pied Hornbill was recorded south of 17° N near secondary forests and fields. The Yellow-browed Bulbul was encountered from all areas between 16° N to 19° N. The Malabar Whistling-thrush was mainly encountered from PAs and RFs south of 17° N. We did not encounter the Black-headed Babbler and Painted Bush-quail from the surveyed sites. Both the species are skulkers and could have been missed.

Tables 7 and 8 summarise the occurrence records of endemic and other important species from PAs and RFs in the northern Western Ghats. For the sake of completeness, we have included records from recent reports by Gole (1998), and Mudappa and Raman (2009) as they refer to the same study area. The results indicate that among the PAs, Chandoli, Koyna, and Radhanagari support the maximum number of endemic birds, while among RFs, Amba, Amboli, Chandgad, and Sawantwadi have the maximum number of endemic birds. All these sites are located south of 18° N.

Records of Uncommon Bird Species

During the survey, we recorded a few species not commonly reported from the Western Ghats region of Maharashtra. Amur Falcon *Falco amurensis*, a passage migrant, was recorded from Harishchandragad Kalsubai Sanctuary and the Japanese Buzzard *Buteo buteo japonicus* was seen at Radhanagari. The Black-naped Oriole *Oriolus chinensis* has patchy and uncertain distribution within the country (Rasmussen and Anderton 2005). Butler (1884) recorded it from Ratnagiri. We saw eight individuals at SGNP and Tungareshwar Sanctuary. The Brown-breasted Flycatcher *Muscicapa muttui*, a species of evergreen forests of southern Western Ghats, was recorded from Koyna during the survey. There are old records of Asian Fairy Bluebird *Irena puella* from Ratnagiri and Mahabaleshwar (Ali and Ripley 1987). We recorded five individuals of Fairy Bluebird from the RFs of

Table 10: Threat scores in Reserve Forests

Sites	Development Projects	Encroachment	Biotic Pressure	Tourism	Poaching Hunting
Lonavala	High	Low	High	High	High
Mulshi	High	Low	High	High	High
Mahabaleshwar	High	Low	High	High	Low
Raireshwar	Medium	-	Medium	Low	-
Sinhagad	Medium	Low	High	High	Low
Durgmanwadi	High	-	Very High	-	High
Kasarsada	High	-	Medium	-	Medium
Chandgad	Low	Low	Medium	-	Medium
Amba	High	-	High	High	-
Amboli	High	-	Medium	High	Medium
Sawantwadi	High	Low	High	Medium	Medium

'-' indicates not observed/reported

Sawantwadi. Jerdon's Nightjar *Caprimulgus atripennis* was recorded from Phansad and Koyna Sanctuaries. Besra Sparrowhawk *Accipiter virgatus* is not recorded commonly from the northern Western Ghats. We recorded the species from Bhimashankar Sanctuary, HKWLS, and Kasarsada. Although we could not locate the Sri Lankan Frogmouth *Batrachostomus moniliger*, there are confirmed records of its presence from Chandoli, Phansad, and Amboli (Varad Giri, pers. comm.). We had frequent sightings of the Blue-bearded Bee-eater *Nyctyornis athertoni* from Chandgad and Kasarsada RF.

Anthropogenic Pressures inside Protected Areas

Tables 9 and 10 describe the types and severity of anthropogenic pressures in the surveyed areas. Recently, windmills have been set up on the southern boundary of Bhimashankar and the construction of an approach road to the windmill site has resulted in felling of a large number of trees in the area (Madhav Gadgil, pers. comm.). The construction of a state highway from Ale Phata to Murbad, which borders the southern boundary of HKWLS has resulted in degradation of Malshej Ghat forests of the Sanctuary – a corridor between HKWLS and Bhimashankar. In Chandoli, an active bauxite mine on the southern boundary of the sanctuary is the main commercial project in the area. Throughout the day, trucks with bauxite travel up and down the Udgiri-Gothne road, causing immense air and noise pollution. The forests surrounding Gothne appear degraded and disturbed due to mining activity. Anthropogenic pressures from local communities in terms of livestock grazing and firewood collection were high mainly in HKWLS and Bhimashankar. In Bhimashankar, the local villagers have started to sell firewood and stems of *Thelepaepale ixocephala* (Wayti in the local language) for raising tomato crops in the plains. This has created a lot of disturbance to the sanctuary vegetation. In Bhimashankar, temple tourism is a serious problem because a large number of people camp and cook inside the forest, which results in disturbance and pollution. Hunting of birds for meat was observed from most PAs. The Katkari and Thakar communities of Bhimashankar and HKWLS are habituated to hunting birds and animals. We recorded many traps for junglefowl, hare, sambar, and mouse deer in Bhimashankar. In Harishchandragad, young boys from Ratanwadi and Thakkarwadi roam the whole day with catapults, hunting many species of birds. However, Chandoli, Koyna, and Radhanagari are relatively well-protected and do not have serious threats to the habitat.

Anthropogenic Pressures in Reserve Forests

The major threat to forests in Lonavala, Amba, Mulshi, and Sawantwadi is from commercial resorts that have been built by clearing native forests. In Tamhini, there is a breeding colony of Long-billed Vulture and a probable nesting site of Great Pied Hornbill. However, this area has become overcrowded due to tourism, which has disturbed the tranquil habitats of Mulshi and Tamhini region. The Hirpude and Velhe regions near Raireshwar are degraded due to intense grazing pressure. On the Raireshwar plateau, people come to collect grass and medicinal plants, which causes serious disturbance to ground birds. Sawantwadi forests have an interspersed landscape of agriculture, private forests, and reserve forests. The private forests that are frequented by Great Pied Hornbill and Black Eagle (this survey) are now fast disappearing, as many of them are being converted to coconut, areca nut and oil palm plantations. If this trend continues, the Sawantwadi region will have no natural habitat left for hornbills.

DISCUSSION

With human pressure on land rising, many ecologically rich areas are under serious threat of possible extinction of species. Under the circumstances, it has become imperative for conservationists to identify and prioritise sites that require immediate conservation action in order to protect their uniqueness in terms of the species, habitat, or the ecosystem services they support. The biodiversity hotspot approach (Myers 1990), using the presence of endemic species, has become a globally accepted procedure for identifying priority areas for conservation action, as it helps in defining investment priorities at the regional scale (Myers *et al.* 2000; Turner *et al.* 2007). Being in the forefront of the entire Western Ghats, the Western Ghats region of Maharashtra are vital to zoogeography considerations. From 1987 to 2005, a marked decrease (0.79%) of dense forest and increase (0.45%) of open forest has been reported from Western Ghats region of Maharashtra, indicating severe anthropogenic pressures on the habitat (Panigrahy *et al.* 2010). Using the presence of endemic and other important birds, we highlight the importance of protecting the forests for bird conservation in Western Ghats region of Maharashtra.

Impact of Habitat on Species Richness

Chandoli, Koyna, and Bhimashankar had higher richness as these areas have many patches of undisturbed and mature forests and are also larger than the isolated areas of SGNP and Phansad. Bird species richness is known to be associated with the size of the forest patch, composition and structure of the forests, availability of contiguous forest areas, and proximity to well-wooded, undisturbed forested areas (Ambuel and Temple 1983; Mehta 1998; Raman 2006). The most anomalous result was the low ranking of Radhanagari

Table 11: Scores for ecological richness and threat factors of Protected Areas

Site	Score for Species Richness	Score for Endemic Species	Score for Other Species	Score for Threats	Total Score
HKWLS	2.3	1.5	0.8	3	7.6
SGNP	2.7	0.8	0.0	3	6.5
Bhimashankar	2.7	1.5	1.5	3	8.7
Phansad	2.7	1.1	0.8	1	5.6
Koyna	2.6	2.6	2.3	1	8.5
Chandoli	3.0	3.0	2.3	1	9.3
Radhanagari	2.3	2.6	2.3	1	8.2

HKWLS=Harishchandragad-Kalsubai Wildlife Sanctuary; SGNP=Sanjay Gandhi National Park

Table 12: Scores for ecological richness and threat factors of Reserve Forests

Site	Score for Species Richness	Score for Endemic Species	Score for Other Species	Score for Threats	Total Score
Lonavala	2.9	3	2.3	3	11.2
Mulshi	2.4	1.1	1.5	3	8
Sinhagad	2.3	0.4	-	2	4.7
Raireshwar	2.1	0.8	-	2	4.9
Mahabaleshwar	2.1	1.1	1.5	3	7.7
Amba	2.7	1.5	2.3	3	9.5
DMW	1.8	0.8	0.8	2	5.4
Amboli	2.1	1.5	2.3	3	8.9
Kasarsada	1.9	1.5	0.8	2	6.2
Sawantwadi	3	1.1	2.3	3	9.4
Chandgad	2.5	1.1	3	3	9.6

DMW=Durgmanwadi

Sanctuary. A possible explanation is that the survey was carried out in limited habitats due to logistic constraints, therefore the number of species recorded was low. Lonavala recorded the highest bird species richness among the RFs. Lonavala, while having some patches with good vegetation, is a relatively fragmented area, interspersed with agricultural areas and human habitations. Generalist species and waterbodies could have added to the species list for this site and increased the species richness. Bird richness was high in Sawantwadi in the Konkan zone and Amba in the Ghat zone because these sites have many undisturbed patches of valley and riparian forests that may have contributed to species richness. Mahabaleshwar Plateau has stunted trees and relatively uniform vegetation, which does not support a diverse birdlife. Kasarsada, Durgmanwadi, and Raireshwar have smaller forest fragments, therefore the species richness was also lower.

Distribution of Endemic Birds in the Western Ghats region of Maharashtra

Among the endemics, the Crimson-backed Sunbird, White-cheeked Barbet, White-bellied Blue Flycatcher, and the Malabar Lark were widely distributed in the survey area. The first three species were recorded from 15° to 19° N, from dry deciduous to riparian forests; the Malabar Lark was recorded from grasslands. Previous records by Fairbank (1876), Gole (1998), and Mudappa and Raman (2009) also report these species to be frequently encountered in the region. Fairbank (1876) reported Malabar Parakeet to be common in Khandala (18° N), but recent reports (Gole 1998; Mudappa and Raman 2009; this survey) report them south of 16° N only. Although the Nilgiri Woodpigeon is often seen in secondary forests feeding on fruiting trees (Authors, pers. obs.), it has been recorded mainly from riparian and undisturbed semi-evergreen forests in Western Ghats region of Maharashtra (Mudappa and Raman 2009; this survey). There are very few records of the Indian Rufous Babbler from this region. It inhabits the understorey of moderately thick forests and secondary forest areas. We recorded the species from Kasarsada RF. This babbler has been reported to be sparsely distributed south of Mahabaleshwar (Gole 1998) and near Amboli RF (Mudappa and Raman 2009). More information is required on its distribution. Earlier surveys (Butler 1884; Fairbank 1876) indicate the occurrence of Great Pied Hornbill, Malabar Grey Hornbill, and Malabar Pied Hornbill from the northern regions till Khandala and Mumbai, but recent surveys (Gole 1998; Mudappa and Raman 2009; this survey) have recorded these species mainly from south of Satara district (16° N). Butler (1884) reported the Malabar Whistling-thrush as common throughout the region, while Gole (1998) reported it as rare in the Western Ghats region of Maharashtra. This survey found it to be uncommon, but not rare.

From the above discussion it appears that forests north of 16° N earlier had suitable habitats for endemic species and hornbills, but in recent times, these habitats have been lost. This is corroborated by Panigrahy *et al.* (2010) who reported highest decrease in forest cover from Thane (29.29%), Nashik (25.25%), and Ratnagiri (16.45%), by comparison of vegetation imageries of 1985 with those of 2005. The decrease in the area of dense forest and increase in open forest and scrublands indicates pressures on the core forested areas. The significant increase in waterbodies is a response to the growing needs of agriculture, industry, and urbanisation. These changes have implications for the presence of endemic species in Western Ghats region of Maharashtra.

Prioritisation of Sites for Bird Conservation in the Western Ghats region of Maharashtra

To assess which areas possess higher ecological values in Western Ghats region of Maharashtra, we carried out a comparative analysis by attributing scores to species richness, number of endemic and important birds recorded in the area. A score was also given for threat level for sites to indicate the urgency for taking action. Values of all ecological parameters were normalised to a maximum of 3. We totalled the scores of ecological values and threats in PAs and RFs to give an overall score out of a maximum possible score of 12 to assess the top ranking sites (Tables 11 and 12).

Sites with higher overall scores had high conservation priority. Among PAs, the conservation priority scores were highest for Chandoli, Bhimashankar, Koyna and Radhanagari, in that order. The high priority for Bhimashankar was partly due to the perceived high level of threat. Among RFs, the conservation priority scores were highest for Lonavala, Amba, Sawantwadi, Amboli, Chandgad, and Mulshi in that order. Lonavala had an exceptionally high score for conservation priority. This was because it scored high for presence of endemic and other important species, and had a high threat score. Mahabaleshwar, though declared an ecologically sensitive area, scored lower than other sites, such as Mulshi and Chandgad, because it had low scores for endemic species and other important species.

Those sites with high ecological threats and low human dependencies are classified as protection-dependent, meaning that efforts need to be directed towards their protection. This category includes the PAs Koyna, Chandoli, Radhanagari, Phansad, and SGNP. SGNP, though having high threat level was classified as protection-dependent because the threats are less due to human dependencies and more due to urban developmental pressures from Mumbai. Protection-dependent sites need Forest Department protection mechanisms to be strengthened. Sites with high human dependencies were classified as conservation-dependent sites, meaning that the people's dependencies need to be addressed and made sustainable. This category includes the PAs Bhimashankar and HKWLS, and all RFs. The actions recommended for these sites include initiating compatible land-use practices that will reduce the pressures of local villagers, along with education and awareness for protection of the habitat.

The inclusion of Chandoli NP and Koyna Sanctuary in Sahyadri Tiger Reserve is a good strategy to protect this entire landscape. Koyna has already been declared an Important Bird Area. We recorded eight endemic species, three important species (Table 9), and one new record from Western Ghats region of Maharashtra (Grey-headed Fish-Eagle) from Chandoli. Hence, we suggest inclusion of Chandoli under the IBA programme.

Many RFs scored high on ecological values, but they also scored high on threat levels. Many RF areas are under pressure due to tourism infrastructure and developmental projects and urbanisation. Therefore, we suggest all the RFs be included in the conservation-dependent category. The role of RFs is vital in ensuring corridors between protected areas and safeguarding the environment. The Environment (Protection) Act, 1986 (EPA) is an official legislation constituted to regulate environment degradation and pollution. Under the EPA, an area can be declared as an Ecologically Sensitive Area (ESA) if it supports endemic or rare species, rare habitats, or geomorphic formations (Kapoor *et al.* 2009). A good way to protect them from further commercial exploitation would be to declare them as ESAs. Mahabaleshwar is already a declared ESA. Based on the results of our survey we recommend that Amba, Lonavala, Mulshi, Amboli, and Sawantwadi RFs be considered for declaration as ESAs since these areas have extensive forests rich in bird species with presence of several endemic birds. Lonavala scored the highest (11.2) in terms of conservation priority. Lonavala has been declared as an EBA, IBA, and Important Plant Area (Islam and Rahmani 2004). However, the process of urbanisation at Lonavala continues unabated. The Forest Department should make use of provisions such as IBA and ESA regulations to curb further commercial development in Lonavala.

Although the forests of Amboli-Sawantwadi region are fragmented and under pressure from commercial development, the bird species richness is high at these sites. A possible explanation is overall contiguity of the landscape and proximity to undisturbed forests of northern Goa and Karnataka. The low-altitude forests in the Konkan zone also tend to be taller, have more structural and species diversity compared to the forests in the Ghats zone, further contributing to bird diversity. Ghate *et al.* (1994) has mentioned that vegetation in Amboli-Sawantwadi region is more similar to southern Western Ghats and therefore the faunal composition also may be similar to that region. As mentioned earlier, species like the Malabar Trogon, Asian Fairy-Bluebird, Black-crested Bulbul, Brown-breasted Flycatcher, and Blue-bearded Bee-eater were not recorded north of Satara district. Bhimashankar, SGNP, Koyna, and Radhanagari Sanctuary, and Lonavala are already IBA sites. We suggest that Sawantwadi region be considered for inclusion under the IBA programme. Sinhagad also has good potential for supporting higher numbers of forest species and should be taken up for conservation action at the earliest. Raireshwar is an important high altitude plateau, but is in an advanced state of neglect. The Forest Department needs to take up intensive protection of the Raireshwar landscape. Generally, in RFs, conservation through community participation, monitoring land-use, protection of private forests, and regulation of commercial development and tourism are necessary for long-term conservation of birds in Western Ghats region of Maharashtra.

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BREEDING OF SPOTTED OWLET *ATHENE BRAMA* IN NEST BOXES AND CONSERVATION ASPECTS

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Research and monitoring schemes of birds have shown that the declining species in Asia and Europe are mostly those which are connected to farmland. The use of insectivorous birds like Spotted Owlet *Athene brama* as bio-control agents is beneficial, both economically as well as ecologically, in controlling rodent and insect pests. To combat the decline and to conserve beneficial bird species, there is a mandate for testing and evaluation of wooden nest boxes for Spotted Owlet and other beneficial species under the All India Network Project on Agricultural Ornithology. In the present study, we have designed and standardised wooden nest boxes for Spotted Owlet in field areas of Punjab Agricultural University Campus, Ludhiana. The observations on breeding in the nest boxes were recorded for two years in relation to nesting sites which are discussed. This farmer-friendly technology needs to be implemented around the villages to reverse the decline of such beneficial bird species.

Key words: wooden nest boxes, egg shape index, Spotted Owlet, bio-control agent

INTRODUCTION

Agricultural intensification has many aspects like mechanization, increasing use of pesticides and fertilizers. Research and monitoring schemes of birds have shown that the declining species in Asia and Europe are mostly species which are connected to the farmland (Ahnstrom *et al.* 2008; Siriwardena 2010). Intensive agriculture and agriculture related development activities in Punjab have adversely impacted many species of birds decrease in abundances of insectivorous/ predatory birds, which correspondingly has resulted in increased insect and rodent pest problems to crops (Parasharya *et al.* 1994). The use of insectivorous birds like Spotted Owlet *Athene brama* as natural bio-control agents is beneficial both economically as well as ecologically in controlling rodent and insect pests. The Spotted Owlet is widely distributed and the most common of all the owls in India (Ali and Ripley 1983). The Spotted Owlet consumes mainly insects and small mammals; whereas Barn Owl *Tyto alba* and other species of owls eat birds, lizards, and amphibians. Although some information is available about the Spotted Owlet's food habits, less is known regarding its nesting, roosting, breeding, courtship, and mating habits (Ahmed 2010; Kler 2003; Mahmood-ul-Hassan 2008; Pearson 2003). Compared to other owl species, nests of Spotted Owlet are easy to locate as they roost close to their nests during the day and emit loud calls when disturbed. They usually remain inactive during the day, unless disturbed by an intruder, and become active at dusk. Our knowledge of the ecology of Spotted Owlet with reference to our agro-ecosystem is highly fragmentary and incomplete. Knowledge of species feeding, ecology, and reproductive biology is essential to understand its population dynamics, and to resolve related conservation issues (Clark *et al.* 2011; Narang and Lamba 1984; Robert *et al.* 2011).

To combat the decline and to conserve beneficial (to farmers) bird species, there is a mandate for testing and evaluation of wooden nest boxes for Spotted Owlet and other species under the All India Network Project on Agricultural Ornithology. Supplementing natural tree cavities with wooden nest boxes has been used as a conservation strategy for many obligate tree-hole, cavity, or secondary cavity nesters, with success in halting or even reversing population decline (Malaza 2010; Sengupta 1976; US Fish & Wildlife Service 2008, 2012). The Spotted Owlet uses tree cavities, cracks, and recesses in building walls, rocks, and cliffs for nesting and is strongly associated with agricultural landscapes.

The present study provides some data on the breeding biology of Spotted Owlet in wooden nest boxes installed at the agricultural field area of Punjab Agricultural University, Ludhiana during 2010–2011.

MATERIAL AND METHODS

The study was carried out in the campus of Punjab Agricultural University (PAU), Ludhiana (30° 56' N; 75° 52' E; 247 msl) during 2010-2011. The campus has a large stretch of agricultural fields, orchards, woodlands, and fish and poultry farms, in addition to a number of buildings.

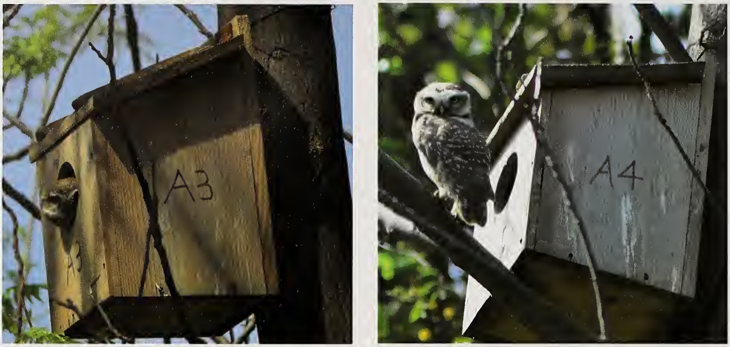

Fig.1: Spotted Owlet occupying the nest boxes

This study to standardise the use of wooden nest boxes by birds (species-wise) is being conducted for over six years at different locations: farmlands and research fields. A total of 62 artificial wooden nest boxes were installed at six different locations, i.e., agro-forestry area, agricultural fields with tree line, vegetable farms-cum-orchards, fodder-cum-orchard area, vegetable farm and poultry farm of the University. These were categorised into four habitat types, i.e., agriculture field (A), agricultural field with tree line (B), small vegetable fields (C), and agro-forestry area (D). These nest boxes were installed at heights ranging from *c.* 2.5 to 6 m on the trunk as well as branches of trees in the study area (Fig. 1). Preference was also recorded for nest visibility (%), tree type (deciduous / evergreen) and habitat types A to D.

Each box measured 30 cm deep, 23 cm wide with an opening of 7.5 cm at a height of 12.7 cm in front, and a lid of 25 cm x 32 cm with two hooks for fixing the box on a tree. The nest boxes were reinstalled and/or cleaned in September in 2009 and 2010, giving the birds ample time to explore possible nesting sites before the onset of the breeding season, and to become accustomed to these wooden nest boxes in their environment.

RESULTS AND DISCUSSION

Of the 62 nest boxes installed, 10 were occupied by the Spotted Owlet. Nest boxes were monitored once/twice a week before egg-laying and on every 2nd or 3rd day during the egg-laying period (Tables 1, 2). In two cases, the Spotted Owlet was observed occupying nest boxes previously occupied by Common Myna *Acridotheres tristis* using the nesting material of the myna. The nesting material comprised small pieces of polythene and a few feathers in some of the nest boxes. In one instance, eggs were laid twice in a box; it could not be determined if the same breeding pair had reared the second clutch.

A total of 35 eggs and 15 young were recorded during this study (Figs 2, 3). The dimensions of 21 eggs were noted and this formed the basis of further analysis. The clutch size ranged from 2–4 and mean egg measurements were: width 26.41 mm, length 31.25 mm, and weight 11.923 gm. The minimum and maximum values of egg parameters were width (24.01 mm and 28.29 mm), length (29.01 mm and 34.56 mm) and weight (9.012 gm and 14.103 gm). The mean Egg Shape Index (ESI) was 84.662. Jadhav and Parasharya (2003) reported the average egg size of Spotted Owlet in nest box as 30.9 x 26.3 mm at Anand, Gujarat. A previous study at Punjab Agricultural University (PAU), Ludhiana (Kler 2004), on the breeding of Spotted Owlet in nest boxes had shown that the clutch size, average egg size, incubation period and nesting period was 3, 31.20 x 26.68 mm, 21 days, and 28–29 days, respectively. The average egg size (31.25 x 26.41 mm) recorded during the present study was comparable with the previous work at PAU Campus, Ludhiana. Incidence of predation was observed. Of the total 35 eggs, 16 eggs went missing, while 4 eggs failed to hatch. Failure of egg incubation may be attributed to improper incubation. There were noticeable changes in chick plumage 10 days after hatching. The 15 day old nestlings had greyish-brown plumage with whitish spots, while the inner parts were mostly white with

Table 1: Detailed description of four artificial nest boxes occupied by Spotted Owlet *Athene brama* at different sites in PAU field area during in 2010

Sr. No.	Site	Tree	Height of the box	Direction of opening of nest box	Tree Canopy Open (O)/ Closed (C)	Deciduous (D)/ Evergreen (E)	No. of clutches	No. of eggs	No. of young	No. of eggs predated	No. of eggs failed to hatch	Total no. of nest boxes installed at site	Area type*
1	I	Eucalyptus	6.09	N	O	E	1	3	3	0	0	4	A
2	II	Eucalyptus	5.48	NW	O	E	1	2	2	0	0	4	A
3	III	Dek	4.57	S	O	D	2	6	1	5	0	6	B
4	IV	Tahli	3.65	N	O	E	1	3	2	1	0	12	A

Table 2: Detailed description of six artificial nest boxes occupied by Spotted Owlet *Athene brama* at different sites in PAU during 2011

Sr. No.	Site	Tree	Height of the box	Direction of opening of nest box	Tree Canopy Open (O)/ Closed (C)	Deciduous (D)/ Evergreen (E)	No. of clutches	No. of eggs	No. of young	No. of eggs predated	No. of eggs failed to hatch	Total no. of nest boxes installed at site	Area type*
1	I	Dek	5.18	W	O	D	1	4	0	4	0	6	A
2	II	Lasura	3.96	E	O	E	1	3	3	0	0	10	B
3	III	Dek	4.57	NW	O	D	1	4	4	0	0	5	B
4	IV	Jamun	4.57	NE	C	E	1	2	0	2	0	5	B
5	V	Dek	5.48	E	C	D	1	4	0	4	0	5	C
6	VI	Dek	3.65	E	C	D	1	4	0	0	4	5	B

* Area type: A = Agricultural field
B = Agricultural field with tree line
C = Small vegetable fields

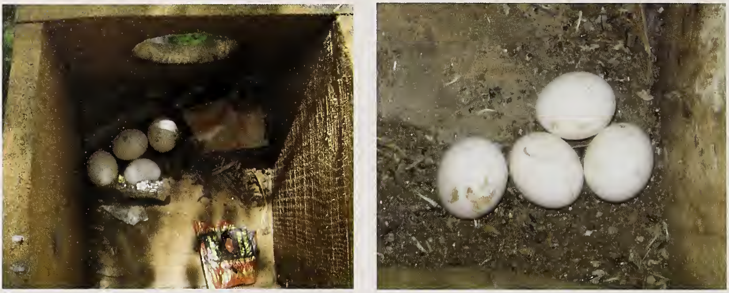

Fig. 2: Eggs of Spotted Owlet in the nest box

dark brown specks. The fully grown chicks flew out of the nest when they were 28–29 days old. Kler (2004) had reported aggression of the parent bird towards the observer, which was not encountered in this study.

The incidence of predation ranged from 0–100%. Of the 10 boxes occupied by the Spotted Owlet, two nests had 33.3% and 83.3% egg predation, four nests had 0% egg predation, three nests had 100% egg predation, and in one nest all eggs failed to hatch. Overall, the incidence of egg predation, successfully hatched eggs, and incubation failure were 45.71%, 42.83%, and 11.42%, respectively. House Crow and Common Myna were observed hovering around or pecking at nest boxes. The breeding success was 57.14% in 2010, 71.42% in 2011, and overall breeding success during the study period was 64.28%. Average height of nest boxes occupied by the Spotted Owlet was 4.7 m.

Of the 10 boxes occupied by Spotted Owlet, five were on Dek (*Melia azedarach*), two on Eucalyptus (*Eucalyptus citriodora*) and one each on Tahli or Sheesham (*Dalbergia sissoo*), Jamun (*Syzygium cumini*), and Lasura (*Cordia myxa*). Open canopy was favoured by 70% of the occupants, compared to closed canopy (30%). Equal preference was observed for deciduous and evergreen trees. Nest box occupation was 50% for type B, 40% for type A, 10% for type C and 0% for D type. Type B habitat consisted of fields with multiple cropping patterns (2–3 seasonal crops per year)

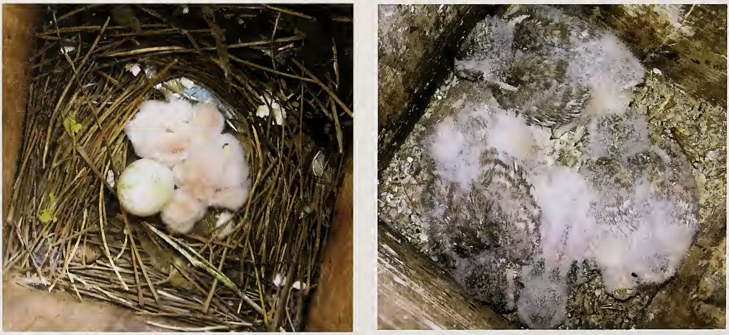

Fig. 3: Young of Spotted Owlet in the nest box

and supported diverse animal/insect fauna. Easy availability of food leads to a preference for type B habitat. Incidentally, at three locations, two nests of Common Myna and one nest of Night Heron (*Nycticorax nycticorax*) were observed on the same tree occupied by the Spotted Owlet.

Ten wooden nest boxes each were also installed at farms in village Mehalkhurd (district Barnala) and village Bhattian (district Gurdaspur). Spotted Owlet was recorded breeding in two boxes installed on a Dek tree about 5 m above the ground at Bhattian village. Clutch size was 3; ESI was 85.302.

The findings suggest that the Spotted Owlet's ability to suppress insect and rodent activities could be used for management of pest populations of agro-ecosystems, resulting in ecological and economic benefits, and as alternative to chemical pesticides. Inversely this farmer-friendly technology needs to be implemented at the village level to reverse the decline of such beneficial bird species.

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BIRD STRIKES TO AIRCRAFT AT NIGHT AND THEIR MANAGEMENT, FOCUSING ON RED-WATTLED LAPWING *VANELLUS INDICUS* (BODDAERT)

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Bird strikes cause considerable damage to aircraft and substantial numbers of strikes take place at night. While the problem during the day is relatively manageable, strikes at night have to be addressed differently. An analysis of the historical data indicated that Red-wattled Lapwing *Vanellus indicus* caused the highest number of strikes. To find ways of reducing strikes from this species, its behaviour and activity pattern was observed periodically, and from review of literature. The strikes reduced after adopting preventive measures during nights around full moon.

Key words: bird-hit, Indian Air Force, full moon night, Red-wattled Lapwing

INTRODUCTION

Bird strikes to aircraft are a natural hazard in aviation and cause considerable damage to aircraft resulting in economic loss and loss of human life. In case of military aviation, the aircraft is not available for operations for the period of repair. This has a bearing on the combat potential and training schedule of the forces. Bird strikes happen both during the day and night. During the day the problem can be fairly managed through birdwatchers with wireless radio communicators who report the presence of birds in the approach or take off path; accordingly, necessary changes are made in the aircraft is landing or take off. Bird strikes take place both during the day and night, about 10% occurring at night. This brought up the need to investigate the problem in a systematic way, understand it and find appropriate solutions to avoid the incidents.

MATERIAL AND METHODS

The study involved collation of historical data on the bird species involved in bird strikes during nights, available at various air force stations. The species involved in bird strikes during 2011 were identified with the help of LaCONES (Hyderabad). Earlier identifications were made at the station level looking at the carcass or through comparison with museum specimens at the Bombay Natural History Society (BNHS). The data showed that the Red-wattled Lapwing was involved notably in night bird strikes. A review of literature on the species was carried out. The dates, from 1995, on which bird strikes by lapwings occurred during nights were recorded. The strike dates with reference to their breeding and post breeding cycle were also examined. Field observations were made on the activity / behaviour of the species in some Air Force stations, both in the general areas and in the aircraft manoeuvring areas (Fig. 1).

Upon observing higher bird activity around full moon nights, 'cautionaries' (a term used in aviation on issue of specific caution at a place for a specific time period) were issued to restrict operations on nights around the full moon. A mechanism for enhanced vigilance by scanning the runway (RW) with powerful lights, before take offs and landings was also instituted.

RESULTS AND DISCUSSION

Data on 975 bird strikes incidents since 2000 (and 4 incidents since 1995) of stations of the Indian Air Force spread all over the country was collated. Of 975 incidents, species were identified only in 224 incidents. Of the

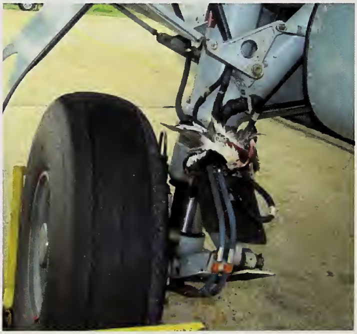

Fig.1: A Red-wattled Lapwing stuck on the landing gear of an aircraft

224 incidences, only 46 were night strikes. Table 1 lists the species involved in the night bird strike incidents and their frequency of strike; of these, the Lapwing species singularly contributed up to 58% of strikes. Lapwings are known to be active during the day and night, and Milson (1984) indicated that they normally feed during the day, but reversed their behaviour for a few days around full moon nights. Their feeding and other activity also depend on other environmental factors such as temperature, rain, and food availability.

Considering this, an analysis was carried out comparing the dates of incidents of bird strikes by lapwing in relation with the dates of full moon nights on the calendar. The findings revealed that bird strikes of lapwings all occurred in the nights around full moon nights (Table 2). Of the 32 incidents involving lapwings (including five prior to 2000), 23 took place between -7 and +7 nights around full moon, suggesting these 14 days as the most vulnerable nights for bird strikes by lapwings. The 'vulnerable period' was further reduced by observing that 20 of these incidents took place between -7 to +1 nights from full moon. Hence, the most vulnerable time period was from 14 nights (which is 50% nights) to 8 nights (*c.* 26% nights) in a month. All the 23 strikes occurred during the breeding season of the species (April-November). In contrast, day strikes occurred during the breeding and non-breeding seasons (data not given here).

The maximum strikes (17/23) occurred between July and September. It was observed that the eggs hatch around July and continues till September at different parts of the country.

Table 1: Bird species involved in strikes against IAF aircraft (at night) and the number of incidents since 2000

Species*	No. of hits
Lapwings (includes Red- and Yellow-wattled)	27
Sparrow and others	4
Owls	3
Nightjars	2
Parakeet	2
Stone Curlew	1
Cattle Egret	1
Bee-eater	1
Pigeon	1
House Swift, Swallow	1+1
Greater Short-toed Lark and Crested Lark	1+1
Total	46

* In addition, there were six strikes by bats

Table 2: Month-wise distribution of lapwing bird strikes during the night*

Month	No. of hits
Apr	2
May	1
Jun	1
Jul	6
Aug	3
Sep	8
Oct	1
Nov	1

*All strikes are around full moon nights (-7 to +7)

Considering these, the field units were given instructions to deploy a Bird Hazard Combat Team (BHCT) during the most vulnerable nights (-7 to +1 night from full moon night). The teams were given powerful lights to scan and scare the birds away, and pre-flight surveys of the ground were done and flying activity was cancelled, if the bird activity was found to be high. Specific instruction was also issued to restrict flying at least +/-1 night around the full moon night. Another labour intensive job was to identify and shift the nests away gradually (100-150 m/day) from the aircraft manoeuvring area. This was expected to keep the birds, especially the chicks away from the vulnerable zone. The stations were instructed to grow long grass (25 to 40 cm) between June and November, as long grass area is not a preferred habitat for this species.

CONCLUSIONS

This study and ensuing precautionary steps taken up by the IAF have resulted in zero night bird strikes by lapwing during July-October 2011. This indicates that the presumptions and inferences made from the study were fairly accurate. However, they need to be evaluated and confirmed over a longer period collecting more robust data. These results will be put into test again in 2012. With the help of DNA bar-coding techniques, the success rate in identifying bird strike species has gone up exponentially and will help in understanding the problem, and arriving at realistic solutions. That will help to ensure safer operations for military and civil flights.

ACKNOWLEDGEMENTS

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STATUS AND POPULATION OF SARUS CRANE *GRUS ANTIGONE* WITH SPECIAL REFERENCE TO THEIR CONSERVATION IN UPPER LAKE, BHOPAL, MADHYA PRADESH

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Sarus Crane *Grus antigone*, the world's tallest flying bird, is a residential breeding crane in India. It has suffered rapid population decline in the last few decades. We discuss the findings of a study conducted on the Sarus Crane from 2008 to 2010 in the Upper Lake, Bhopal, Madhya Pradesh, designated as a Ramsar and Important Bird Area (IBA) site. Census of the Sarus Crane was conducted on foot and by boat. Agricultural crop seeds and their shoots were seen to be preferred by the cranes. General data was collected on the crops cultivated in the peripheral villages and the pesticides used. The highest count 24 was in 2008, and numbers declined in the following years. The Sarus Crane population was observed to increase during summer and decrease in monsoon. Various factors are responsible for the declining population, mainly human interference and use of pesticides on crops around the IBA site. A systematic conservation strategy based on awareness programme is recommended.

Key words: Sarus Crane, Upper Lake, population

INTRODUCTION

Sarus Crane *Grus antigone*, the world's tallest flying bird (Archibald *et al.* 2003) is the only residential breeding crane in India and Southeast Asia. Its majestic presence has graced ponds, rivers and submerged fields, and its call has reverberated across the country for long (Vyas 2001). It is the mascot of our wetland and cropland. Mostly non-migratory in India, it often makes short seasonal movement between dry and wet season habitats. In the 1960s, Ali and Ripley (1983) stated that the Sarus Crane is a common resident throughout the northern parts of the Subcontinent; today its distribution is fragmented. Its population has declined rapidly within a few decades (Choudhary *et al.* 1999). In the past few years the Sarus has lost most of its earlier distribution range.

The present study is a major part of a research conducted from 2008 to 2010. The study aimed to determine the status and population of Sarus Crane in the Upper Lake in Bhopal, besides planning a strategy for the conservation of its habitat.

STUDY AREA

Bhopal is situated on a series of hills interspersed with villages. The area has a dry climate except during the Southwest monsoon. The Upper Lake in Bhopal is the oldest and largest man-made lake in India and is part of the Bhoj wetland. Bhoj wetland is comprised of the Upper and Lower Lakes and was declared a Ramsar site in 2002. The southern part of the Upper Lake is the preferred site for all birds, including the Sarus Crane. More than 160 Sarus Crane (>1% of the reported total population in India) have been counted here, and the wetland has been identified as an IBA (Important Bird Area) (Nandi 2006).

The Upper Lake was constructed in the 11th century by constructing an earthen dam across the Kolar river. Outflow from the Upper Lake, which receives water mainly from the Kolans river drains into Kaliasot river and finds its way to the Yamuna through the Betwa river. The Upper Lake, which is aligned east-west, has a catchment area of 361 sq. km and a surface area of *c.* 31 sq. km. It is situated at 23° 12' – 23° 16' N and 77° 18' – 77° 23' E. The submergence area of Upper Lake at FTL (Full tank level) is 36.54 sq. km and storage capacity is 117.05 million cu. m with maximum depth of 11.7 m.

The Lake supports a wide variety of flora and fauna, and provides an ideal habitat for food and shelter for a large number of bird species. The Upper Lake has a partial urban component in its catchment on the eastern end while the remainder is rural. The south-east part is surrounded by Van Vihar National Park, opposite which are the villages Bishankhedi and Goragaon. A flock of Sarus Crane can be seen at the western end of the Upper Lake near a village where the water recedes during summer. Sixty percent of the catchment area of the lake is predominantly agricultural. The Sarus Crane feeds on agriculture crops, mainly wheat, soyabean, pulses, and seasonal vegetables. During the past few years, the Lake has been subjected to pollution due to use of pesticide, discharge of untreated sewage, and runoff carrying silt, and human disturbance, causing decline in numbers of Sarus Crane.

Some studies were conducted on the avifauna of the Upper Lake. Only one study has been done on Sarus Crane by Nandi (2006), based on their spatial distribution and count, but further study has not been done on this species.

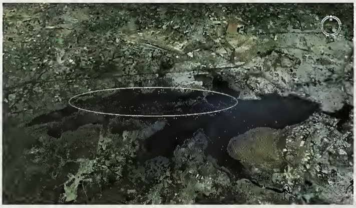

Fig. 1: Upper Lake: Yellow ring indicates Sarus Crane habitat

MATERIAL AND METHODS

Direct total count method (Javed and Kaul 2002) was used for the census. Counts were done on foot and by boat from both east and west peripheries of the Lake. The boat could be used only in winter (post monsoon) when the water level was good. Counts were taken once every month from 06:30-10:30 hrs; counts were also taken randomly when the population changed significantly. The highest count was termed as the total count of the month. General data on different crops cultivated in the peripheral villages and pesticides used was collected during the study period.

RESULTS

It was noticed that the cranes preferred wetlands close to croplands. Their optimal habitat included a combination of small seasonal marshes, floodplains, high altitude wetlands, human-altered ponds, fallow and cultivated lands, and paddy (Nandi 2006). Gole (1989) and Vyas (2001) stated that among the different types of wetland habitats, the Sarus preferred marshes, crop fields and reed beds, especially during summer. The Sarus may be seen in harvested crop fields, feeding on fallen grains, seeds, and insects.

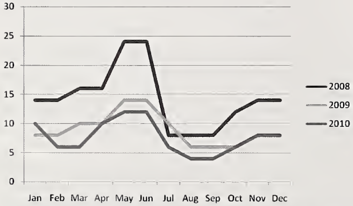

Fig. 3: Monthly record of Sarus Crane population during 2008–2010

M. KHALIQUE

Fig. 2: Sarus Crane *Grus antigone* in Upper Lake, Bhopal

The maximum population of Sarus Crane was observed in 2008, and the minimum in 2010. It was noted that Sarus Crane population increased from March to June every year and subsequently declined. The maximum number (24) was counted in 2008, in May and June, and the minimum (04) was counted in August and September in 2010. It was found that population of Sarus Crane increased during the summer season and started decreasing during monsoon season. The number increased again from the beginning of winter till the end of summer.

The data on agricultural crops and their pesticides was collected during the study period (Table 1). The data revealed that different crops, namely soyabean, wheat, pulses, and seasonal vegetables cultivated seasonally in the peripheral villages Bishankhedi and Goragaon. It was noted that more than five varieties of insecticide and four varieties of weedicide were used on these crops.

Table 1: Table showing season-wise crops and chemical used on it in the study area

Crops	Seasons	Chemicals used	Nature
Wheat	Oct.-Mar.	-	-
Gram (Channa)	Oct.-Mar.	Endosulfan, Epichlorohydrin	Insecticide
Soyabean	Jun.-Nov.	Chlorimuron ethyl	Weedicide
Pulses	Jun.-Oct.	Endosulfan, Malathion	Insecticide
Corn (Makka)	Jun.-Aug.	Emamectin benzoate	Insecticide and acaricide
Vegetables	Jul.-Aug.	Endosulfan Chlorimuron ethyl Imazethapyr Sulfonylurea Dichlorvos	Insecticide Weedicide Weedicide Weedicide Insecticide

DISCUSSION

The Sarus Crane population in Upper Lake, Bhopal, has declined with every passing year. Various factors such as poor monsoon, human encroachment on the periphery of the lake, pesticide use on crops of peripheral areas and nearby agricultural fields, cattle grazing and stray dogs in Sarus nesting areas, activities of fishermen, mechanical and manual desiltation programmes, and pollution are responsible for the declining population of the Sarus Crane. Pesticides and weedicides are possibly the biggest threat for Sarus as it feeds on seeds and shoots of crops.

The population at the Upper Lake increases during summer when the aquatic fauna is exposed due to low water levels and drying up of nearby water sources. It decreases during monsoon as seed sowing during this period result in the distribution of the birds in different crops fields. The population gradually rises again during winters due to local migration. The declining population during monsoon is a cause for concern, and indicates the need for a conservation strategy based on community involvement and general public awareness, which emphasise protection and proper habitat management for the Sarus Cane in the Upper Lake.

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Cover Photograph: Himalayan Salamander *Tylototriton verrucosus* By Dhritiman Mukherjee

Editorial

Conservation Drones: A new tool for conservation action

Collecting good and timely field data is important for proper conservation initiatives. Lack of data is often given as an excuse by decision makers for not taking conservation action. Scientists and conservationists use various methods to collect field information, mostly with limited resources, both human and financial. With increasing restrictions on research permission, particularly for invasive research, it becomes extremely difficult to collect good information that can be used to convince decision makers such as forest officials. National parks and tiger reserves, where some semblance of natural habitat survives, are becoming out of bounds for ground research.

There appears to be great resistance to the use of new technology in wildlife research by the government. For example, satellite tracking of animals was pioneered in the USA in the early 1970s and became popular for bird migration studies from the early 1990s; the Ministry of Environment and Forests (MoEF), however, resisted the use of satellite tracking for many decades, for security reasons, until they allowed it on an 'experimental basis' in 2001. Similarly, their initial reaction to freely available Google maps was to block them for security reasons. Fortunately, technology bulldozed this ill-conceived opposition and now the Government of India is one of the biggest users of satellite maps, employing them to study various aspects from the forest cover to urban planning.

A new technology of using unmanned drones for conservation purposes is on the anvil. Unmanned Aerial Vehicles (UAV) or Conservation Drones is still in the experimental stage but I foresee a huge potential, from catching poachers to surveying difficult terrain for conservation planning. Drones have also shown tremendous scope to study vehicular traffic, crowd control, and disaster management. There is a website www.ConservationDrones.org whose mission is "to share our knowledge for building low-cost Conservation Drones to help conservation workers and researchers in developing countries do their jobs a lot more effectively and cost efficiently."

Due to misuse by the military, the very idea of drones sends a negative feeling among the public. However, Lian Pin Koh, Assistant Professor of Applied Ecology and Conservation, Swiss Federal Institute of Technology, Zurich, and Serge Wich, Professor at the Research Center in Evolutionary Anthropology and Paleoecology at Liverpool John Moores University, showed that drone technology, based on hobby aircraft models, can be used for conservation purposes. The technology was first used in the Sumatra Rainforest to photograph Orangutan nests on tall trees, which were difficult to identify from the ground. The Conservation Drone, fitted with camera and GPS came up with numerous pictures of nests which gave data on the number of Orangutan surviving in the area. During 30 flights, it collected hundreds of photographs and hours of video footage. It also showed the devastation of the rain forest due to oil palm plantation and illegal logging. Since the successful experiment in Sumatra, conservation drones have been used in Malaysia, and some countries in Africa.

In South Asia, Nepal was the first country to experiment with conservation drones. In June 2012, a conservation drone was successfully flown in Chitwan National Park, under the famous Terai Arc Landscape Programme of WWF-Nepal. The aim is to deploy these drones to check the movements of poachers and encroachers. Once a poacher gang is located, the ground staff can reach quickly as the drone transmits the GPS location. A successful test flight undertaken in Kaziranga NP shows that Conservation Drones could be a potentially useful tool in the fight against rhino poachers.

A Conservation Drone can be pre-programmed to travel particular routes and take aerial pictures and video footage. This will be of use to gather geospatial data of inaccessible areas. It can also be used for Citizen Science programmes, involving amateurs to analyze the high-resolution data (images/videos) collected by the Conservation Drone. These high-resolution images can provide information about the condition of forests and changes, if any, taking place due to fire, encroachment, invasive species, or a natural calamity. Conservation Drones will be particularly useful to monitor encroachment as they can provide monthly or even weekly data (depending on how frequently they are flown). Timely ground action based on high resolution images can prevent further damage.

My particular interest is to use camera-fitted Conservation Drones to fly over grasslands to locate Bengal Florican. The Bengal Florican *Houbaropsis bengalensis* lives in medium to tall wet grasslands of India and Nepal terai, and the Brahmaputra flood plains. These grasslands are also inhabited by Tiger, Rhino, Elephant, and Wild Buffalo, so ground surveys are not always possible. The bird is seen either just after burning of the grassland when the grass is very short, or when it displays by jumping above the grasslands. I will be interested to experiment if a Conservation Drone can be used to locate Bengal Florican. If this is possible, it will help to survey the large number of grasslands on river islands (*chapori*s) of the Brahmaputra river that come up every year just after the monsoon floods, which are otherwise difficult and/or time consuming to approach. Once Bengal Floricans are located, ground truthing can be done wherever possible. Similar studies can be done on other animals such as Rhino, Elephant, Swamp Deer, Wild Buffalo, and to keep an eye on poachers and encroachers.

As this technology is still in the experimental stages for conservation purposes, it will be good if India takes a lead. A mature approach would be for the government to set up a policy and rules governing the use of drones for civilian and research purposes, so that India leads the way in promoting this nascent technology for the benefit of conservation. But, will the jittery mandarins in the corridors of power in Delhi allow this, or will Indian field conservationists have to wait for a couple of decades for this technology to overcome all the difficulties? This is the big question.

Asad R. Rahmani
(With inputs by Dr. Christy Williams)

THE DISCOVERY OF THE EGG OF JERDON'S COURSER *RHINOPTILUS BITORQUATUS* (BLYTH 1848)

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The Jerdon's Courser *Rhinoptilus bitorquatus* (Blyth 1848) was thought to be extinct until it was rediscovered in 1986. The species is poorly known despite a number of studies and, until now, its egg has not been seen by any ornithologist. We report here the discovery of a Jerdon's Courser egg at Aberdeen University in Scotland, the identification of which was confirmed by DNA analysis. The egg was collected by Ernest Gilbert Meaton, a veterinary surgeon at the Kolar Gold Fields in Karnataka (India), probably in 1917, most likely within 100 km of the Gold Fields. Meaton's collection was purchased by George Falconer Rose, given to Aberdeen Grammar School in 1919, and transferred to Aberdeen University in the 1970s. It is hoped the discovery will assist in the conservation of this Critically Endangered species.

Key words: Jerdon's Courser, egg, Karnataka, Aberdeen University

INTRODUCTION

The Jerdon's Courser *Rhinoptilus bitorquatus* (Blyth 1848) is an iconic Indian endemic, formally listed as Critically Endangered, with its presumed current distribution restricted to a small area in the Eastern Ghats of Andhra Pradesh (BirdLife International 2010). The species was recorded only a few times up to 1900 in the Penner river catchment (southern Andhra Pradesh), close to the Godavary river (near Sironcha, Gadchiroli district, Maharashtra, and near Bhadrachalam, Khammam district, northern Andhra Pradesh), and near Anantapur (southern Andhra Pradesh). The early records of the species have often been misquoted and have recently been reviewed by Knox (accepted). Through the early and mid 20th century, the Jerdon's Courser was thought to be extinct (e.g. Fuller 1987), until it was dramatically rediscovered near Cuddapah by Bharat Bhushan in 1986 (Bhushan 1986a, b). Research on the bird since then has been hampered by the species' nocturnal habits, the scrub jungle in which it lives, and its apparent rarity. The Courser is difficult to see and much of the limited recent information has come from the use of tracking strips to detect the footprints of passing birds, automatic camera traps and tape surveys (Jeganathan *et al.* 2002; Jeganathan and Wotton 2004). The species is one of the rarest birds in the world and its future is far from secure (Anon. 2010). Providing adequate protection for the Courser is made harder by the lack of understanding of the species' biology and habits. Although there are anecdotal accounts of eggs (Baker 1929; Baker and Inglis 1930; Samant and Elangovan 1997), none had been seen by an ornithologist until now. We report here the discovery of the first, and so far only known, authenticated record of the egg of the species.

The discovery of the egg of Jerdon's Courser

The Museums at the University of Aberdeen hold the sixth largest collections in Scotland, including the only significant international zoological collection in the north of Scotland (www.abdn.ac.uk/museums). In 2008, AGK visited one of the storerooms of the Zoology Museum and was browsing several drawers of uncatalogued birds' eggs when he noticed one labelled 'Jerdon's Courser', with a note 'Egg unknown to Br India Fauna'. In view of the bird's near-mythical status and global rarity, a check of the literature confirmed that the egg of this species was not just unknown to Blanford (1898) and Baker (1929), compilers of the two editions of THE FAUNA OF BRITISH INDIA ... BIRDS, the egg had apparently never been seen by any ornithologist, and there were no eggs known in any museums.

Without measurements, description or photographs with which to compare the egg, the question arose as to whether it had been correctly identified, and if it had, where had it come from?

Identification

From the outset, the shape and size of the putative Jerdon's Courser egg (Fig. 1) was found closely to match that of the African Bronze-winged Courser *R. chalcopterus* in Oates (1902), and the markings, though less dense, showed notable similarities to it. *R. chalcopterus* is a sister species to Jerdon's Courser (Maclean 1996). The dimensions of the egg closely matched those of *R. chalcopterus* as given in Schönwetter (1963). The egg was initially compared to those of other species of coursers of the genera *Cursorius* and *Rhinoptilus*, pratincoles *Glareola*, and possible confusion species breeding in India, such as the lapwings *Vanellus*, using

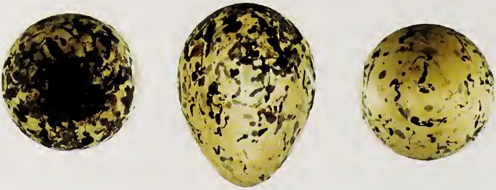

Fig. 1: The only known egg of Jerdon's Courser *Rhinoptilus bitorquatus*, collected by E.G. Meaton, probably in 1917 and most likely within 100 km of the Kolar Gold Fields, Karnataka, India (University of Aberdeen ABDUZ: 70169). Length 35.5 mm x 26.5 mm. Photographs: Kim Downie, University of Aberdeen

Aberdeen University's egg collection, as well as published and online resources. Douglas Russell of the Natural History Museum, Tring, provided photographs of the eggs of the other three *Rhinoptilus* species. When these failed to suggest an obvious mis-identification, and supported similarities to *chalcopterus,* the egg was taken to the Natural History Museum for direct comparison with more courser eggs and a wider range of species. Here, a thorough search of the collections and comparisons with possible confusion species again confirmed that the egg, while different, was closest to those of *chalcopterus* in shape, size, colouring, and surface texture. There remained little doubt at this stage that the egg had been correctly identified, a point supported by the credibility of the evidence from the other eggs of the collection in which it has been found, which had, by now, been catalogued.

DNA-based identification

Recent advances in so-called 'DNA barcoding' allow any sample of unknown species provenance to be identified by comparing specific parts of its DNA base sequence with databases of reference sequences populated by recognised taxonomic authorities. Chilton and Sorensen (2007), and Lee and Prys-Jones (2008) recently demonstrated the ability to obtain useful DNA from museum egg shells. As such, we used DNA barcoding to examine the identity of the putative courser egg. The hole through which the egg had been blown had been carefully covered with a gummed paper disc. This was soaked in distilled water and alcohol, and removed with some difficulty. The hole underneath had been neatly drilled without any significant flaps of membrane showing. The inside of the shell was gently scraped with a clean needle, and the contents shaken out and collected. In parallel, a sample from a toe-pad from a Jerdon's Courser skin held in the Natural History Museum was obtained for comparison (NHMUK 96.7.1.51). DNA was extracted from both egg membrane and toe-pad using a DNeasy DNA extraction kit, according to the manufacturer's protocol, and a polymerase chain reaction (PCR) undertaken according to Piertney *et al.* (2003) to amplify the mitochondrial 16S ribosomal RNA gene using standard avian barcoding primers. PCR products were cloned into a pGEM *E. coli* vector and three amplicon-containing colonies for each sample DNA were sequenced using a 3730 automated DNA sequencer. DNA sequence quality was confirmed by eye from electropherograms, and sequences interrogated using BLAST analysis to confirm 16S identity. The sequences obtained from the egg and the toe-pad were identical, indicating that they had come from the same species, and most similar to *Rhinoptilus africanus* 16S (accession DQ673612.1), the only *Rhinoptilus* 16S sequence on Genbank. As such, it can be concluded that the egg is from a Jerdon's Courser.

Description of the egg of Jerdon's Courser

The egg is short oval in shape (Harrison 1975: 35; Fig. 1), now catalogued as ABDUZ: 70169. It has a non-glossy surface texture, apart from patches apparently covered with surplus from the adhesive used on the gummed paper disc, which had been placed over the blowhole, including partial fingerprints in the adhesive. The egg measures 35.5 mm x 26.5 mm, and weighs 0.76 gm. This compares to averages of 35.5 mm x 26.9 mm for nominate *chalcopterus* and 36.2 mm x 27.0 mm and 0.86 gm for *R.c. albofasciatus* (Schönwetter 1963), a subspecies of *R. chalcopterus* with a similar body-length (Maclean 1996).

The ground colour is an even, pale sandy yellowish, on which are laid brown blotches, compact or elongated in form, occasionally scrawly, and varying in intensity from very dark, almost black, to faint and close to the background colour. Some of the paler markings take on a pale bluish tone. The markings are most intense at the blunt end of the shell; the ground colour is almost completely obscured over an area at the apex about 12 mm in diameter. There are many fewer markings at the widest point of the egg and the pointed end is almost unmarked. The colours and texture closely match those seen in *chalcopterus* eggs, though the latter show considerably heavier markings, more evenly distributed across the shell.

DISCUSSION

The egg is part of a small collection assembled by Ernest Gilbert Meaton, a veterinary surgeon at the Kolar Gold Fields, Karnataka. The collection was purchased by George Falconer Rose, later a Managing Director of Andrew Yule & Co, Calcutta (= Kolkata), and presented to Aberdeen Grammar School, in Aberdeen, Scotland, early in 1919. The collection remained at the school until about 1978, when it was transferred to the Zoology Museum of the University of Aberdeen. A detailed discussion of the provenance of the Meaton collection is given by Knox (accepted). The egg does not carry a date or place of collection, but limited evidence from the other eggs in the collection suggest it was most likely collected in 1917, and probably within about 100 km of the Kolar Gold Fields (Knox accepted).

Samant and Elangovan (1997) included information on nests and eggs of Jerdon's Courser as reported to them by shikaris. Their description of the eggs – 'yellowish with many black blotches; similar to the Red-wattled Lapwing's *Vanellus indicus* eggs, but a little smaller' – closely matches the verified egg described here and enhances confidence in their observations of nests and nesting. Although it is likely that the eggs of Jerdon's Courser will show some variation, knowledge of what a confirmed egg of the species looks like should assist field workers to identify others that they might find. The Kolar Gold Fields are about 200 km SSW from where the birds were rediscovered in 1986, and only 50 km SSW from a recent unconfirmed sighting (Fig. 2 in Anon. 2010). It is possible that Meaton may have collected his egg even closer to the Gold Fields than this, and searches of suitable habitat may be warranted.

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CHEMICAL IMMOBILIZATION OF LEOPARD *PANTHERA PARDUS* IN THE WILD FOR COLLARING IN MAHARASHTRA, INDIA

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Four leopards (*Panthera pardus fusca* (Meyer 1794)) were tranquilised as part of a leopard ecology project at Maharashtra, India, to develop a database from which conservation plans could be developed to manage human leopard conflict. A mixture of Ketamine hydrochloride and Xylazine hydrochloride, at a dose rate of 5 mg and 1.5 mg per kg respectively, were used to tranquilise the leopards for radio collaring. Vectronics GPS plus collars were fitted on the animals. Overall, induction time was within 3–6 minutes, down time 6–15 minutes, lateral recumbency 65–90 minutes, and recovery time was 70–100 minutes when antidote was not used. Yohimbine was used in 2 cases at the rate of 0.14–0.17 mg/ kg body, after which the recovery time was reduced to 35–55 minutes. Temperature, respiration, and heart rate were normal during the procedure. Microchip was fitted for permanent tagging of the leopards. We found that the Ketamine-Xylazine anaesthesia for immobilisation was effective and that Yohimbine can be used to hasten recovery from anaesthesia in leopards. Further studies using more leopards may prove helpful and important in determining better drug dosage and handling methods.

Key words: Tranquilisation, Ketamine hydrochloride, Xylazine hydrochloride, restraint, Yohimbine, drug dosage

INTRODUCTION

The Leopard *Panthera pardus* is the most widely distributed wild cat, and occupies a broad variety of habitats, ranging from rainforests to deserts and from the fringes of urban areas to remote mountain ranges (Kitchener 1991; Nowell and Jackson 1996). The Indian subspecies, *Panthera pardus fusca* (Meyer 1794), is found all across India, absent only in the arid deserts and above the timberline in the Himalaya (Prater 1980). Although the leopard is accorded the highest protection under The Wildlife (Protection) Act (1972), India, it is still severely threatened due to poaching (Athreya and Belsare 2005).

Many studies on leopards have been carried out in other parts of its global range, mainly in Protected Areas (Bailey 1993; Bothma *et al.* 1997; McDougal 1988). There has been only one long-term ecological study of leopards in India (Edgaonkar 2008), which was also conducted in a Protected Area. In India, most of the human-leopard conflict occurs in human dominated landscapes outside Protected Areas (Athreya and Belsare 2006). Developing suitable management strategies outside Protected Areas could be a key factor in the future conservation of leopards (Marker and Dickman 2005; Marker and Sivamani 2009). Not only are detailed ecological studies absent from protected areas, even information from chronically affected conflict areas is lacking. Most of the studies have been restricted to population estimations (Chauhan *et al.* 2005; Edgaonkar 2008; Harihar *et al.* 2009), diet analysis (Edgaonkar 2008; Karanth and Sunquist 1995), and habitat occupancy (Edgaonkar 2008). There is a serious lack of robust ecological information on this species. This is particularly necessary in potential conflict prone areas as proactive mitigation strategies can be devised only with information on the biology of the species.

Our project involved monitoring of leopards that live in potential conflict zones in human dominated landscapes in Maharashtra, western India. As leopards use human dominated landscapes in many areas of Maharashtra (as in other parts of India), four leopards were captured in Ahmednagar and Nashik districts of Maharashtra for collaring with GPS GSM collars to understand their ranging pattern, habitat usage, and diet. In this paper, we report our protocol for immobilising the leopards for collaring and their findings.

STUDY AREA

Ahmednagar is a city of Ahmednagar district situated in the central part of Maharashtra, while Nashik is in the northwest part of the state. The climate is characterised by dryness except during the south-west monsoon season. Three physical divisions namely, Western Hilly Region, Central Plateau Region, and the region of northern and southern plains describe the geography of Ahmednagar district. The entire Nashik district is underlain by the basaltic lava flows, which give rise to tableland type of topography also known as plateau. The total geographical area of Ahmednagar district is 17,04,800 ha, of which 1,37,674 ha is under forests (*c.* 8% of the geographical area). Nashik district has an area of 15,53,000 ha, of which 3,20,668 ha area is under forests (*c.* 20.5% of the geographical area). Agriculture is the main source of earning and sugarcane is the main crop. The maximum temperature in summer is 42.5 °C and minimum temperature in winter is less than 5.0 °C. Relative humidity ranges from 43% to 62%. Rainfall varies from 500 to 2,000 mm per year. Approximately 80% of the human population is rural with farming of sugar cane, millets, and vegetables being the major source of livelihood. Ahmednagar has a human population density of 177 per sq. km, while Nashik has a population density of 393 inhabitants per sq. km (http://ahmednagar.nic.in/).

Livestock play an important role in the agricultural economy of both the districts and constitutes one of the valuable possessions of the farmers and villagers. Most of the agricultural operations such as ploughing, harrowing, irrigation, and transport are carried out with the help of draught animals. The livestock population comprises around 18 lakhs (18,00,000), which includes 9 lakh bovines, 5 lakh goats, 3 lakh sheep, and around 1 lakh buffaloes (http://cultural.maharashtra.gov.in/New_website/index.html). Data suggests that leopards subsist on livestock and domestic dogs in this region (Athreya *et al.* in press).

All the leopards discussed in this manuscript were captured in human dominated landscapes consisting of rural habitations and crop fields with an average population density of 258 people per sq. km.

METHODS

Trapping: All the leopards were captured between May and June 2009. Cages available with the Forest Department with trap release doors at each end and a trigger plate in the middle (Marker and Dickman 2005) were used. The first leopard (M1) and the second (F1) were individuals rescued by the Forest Department from two different wells. The third leopard (M2) was trapped near a cropfield, while the fourth (F2) was captured in a trap placed at the entrance of the house she had entered earlier. M1, M2, and F2 were radio-collared after trapping. It was decided not to put a collar on F1 due to her young age and multiple injuries on her face and body.

Tranquilisation: Silence was maintained as much as possible prior to the immobilisation and the cages were covered on all sides to reduce disturbances to the animals. Only two persons approached the animals to (visually) estimate the weight prior to tranquilisation and others joined only after the animal was completely sedated. Once the weight was estimated based on size, approximate age, and body condition, the drug was prepared and loaded into a 10 ml projectile plastic dart syringe equipped with an 18-gauge needle and injected intramuscularly into the thigh using a blowpipe (http://www.protecwild.com/). During the delivery of the drug, the animal was distracted from one side of the cage and the drug was darted into the intramuscular region of the hindquarters from the opposite side of the cage. The animal was observed periodically by the veterinarian during induction of anaesthesia. We determined if the leopard was safe to handle after tranquilisation by observing its response on being tapped gently with a thin branch from a safe distance. Once tranquilised, the immobilised leopard was placed on a nylon stretcher and carried outside the cage. Care was taken to keep the tongue outside the mouth and to keep the head straightened (for easy respiration). The eyes were covered with a moist towel. Temperature, respiration, and heart rate were recorded every 10–15 minutes. Long acting Penicillin and Doramectin (1 ml intramuscular) were injected in all cases. Topicure spray was applied at the darting site and on any external injury sites on its body. A Trovan ID 100 microchip was inserted at the base of the tail for permanent tagging of the animal. Animals were weighed by a spring scale. Dentition and morphometry were also recorded. Age was estimated based on colour and wear of the tooth, gum recession, wear on pads, and body size and weight (Bailey 1993). Heart and respiratory rate were monitored by stethoscopic chest auscultation and by observing thoracic movements respectively. Temperature was recorded by a thermometer inserted in the rectum. Yohimbine was injected intravenously in two cases after completion of the handling of the animal for reversal of anaesthetic effect. Once the collaring procedure was completed, the animal was placed back into the cage with the rear end placed near the door so that we could continue monitoring of temperature.

Chemical anaesthesia: We anaesthetised leopards with a combination of Ketamine hydrochloride (100 mg/ml) and Xylazine hydrochloride (100 mg/ml). The two drugs were administered intramuscularly at a dosage of 5 mg/kg and 1.5 mg/kg estimated body weight respectively. For each animal, we noted the time when the dose was administered, time of anaesthetic induction, time of complete anaesthesia, time of initial signs of recovery, and time of full recovery. We define induction as the time from injection of the drug until the first symptom, e.g., lip licking. Down time is defined as the duration between initial anaesthetic effects to complete head down. Recumbency period is the time of complete anaesthesia. Recovery time is defined as the time from head up to proper standing. We allowed immobilised leopards to recover in the protected environment inside the cages. When full recovery was observed (e.g., standing without swaying), the animal was released.

Table 1: Overall results of chemical anaesthesia on the leopards

Animal ID.	Sex	Approx age (years)	Approx body weight	Drugs (mg)		Supplementary Ketamine (mg)	Induction time (min)	Down time (min)	Reversal (Yohimbine) (mg)	Lateral recumbency	Recovery time
				Xylazine	Ketamine						
M1	M	8	65	100	325	-	3	6	-	1 hr 40 min	1 hr 10 min
F1	F	3	30	35	130	30	6	15	-	1 hr 30 min	1 hr 40 min
M2	M	3	50	90	250	-	3	7	8	1 hr 5 min	35 min
F2	F	4	35	70	175	-	5	8	5	1 hr 20 min	55 min

Collaring procedure: Vectronics GPS plus collars were fitted on three of the four animals. After the tranquilised animal was removed from the cage and placed on the stretcher and being examined by the veterinary doctor, the other authors started the process of putting on the collar. The first was to measure the circumference of the neck at the narrowest place (close to the ear) and the circumference of the head (closest to the ear). These were noted and the collar was put around the neck of the animal. In all cases, we made sure that there was one finger space between the collar and the neck of the animal. In case of F2 and M2, we made sure that even our knuckles could get underneath the collar as these were relatively younger animals. Once the actual length of the collar was determined, it was removed from the animal, cut and then placed back and screwed on tight.

Release process: Care was taken to cover the trap cages on both sides so that we were not visible to the leopards. The release was done only after making sure that the animal was completely awake. All releases were at night. A rope was tied to the trap door and taken over a pulley that was tied either to a vehicle or a tree, from where the rope was pulled to open the trap door.

RESULTS

We successfully tranquilised four leopards (2 males and 2 females) for the purpose of radio collaring. Immobilisation was indicated initially by moderate salivation, licking of lips, staggering movement, dilatation of pupils, and muscle rigidity. The induction was rapid and smooth in M1, M2, and F2, but was slightly prolonged in F1 due to administration of a slightly low dose, due to her small size. The down time was 6–8 minutes in M1, M2, and F2, and 15 minutes in F1. Overall, induction time was 3–6 minutes, down time was 6–15 minutes, lateral recumbency time was 1 hr 5 min to 1 hr 40 min, and recovery time was 1 hr 10 min to 1 hour 40 min without the use of Yohimbine (Table 1). Yohimbine was used in 2 cases at the rate of 0.14–0.17 mg/kg body weight and reversal took place in 3–5 minutes after the intravenous injection of Yohimbine. It took another half an hour for complete recovery of the leopards from the anaesthesia effect. No convulsion, hypersalivation or vomiting was noticed. We found that 5 mg Ketamine hydrochloride per kg body weight and 1.5 mg Xylazine hydrochloride per kg body weight was effective and safe for successful immobilisation of leopard for radio collaring. Early stages of recovery were indicated by ear-twisting and eye-blinking. They reacted to external stimuli by lifting the head and jerking their legs.

Table 2: Temperature, respiration, and heart rate of the leopards

Animal ID	Temperature (F)	Respiration (per min)	Heart rate (per min)
M1	103.7–103.9	12–14	62–78
F1	104.2–106.9	12–14	75–85
M2	104.1–104.4	14–18	70–72
F2	101.1–101.7	11–16	78–80

Physiological values: The body temperature was high in F1; M1, M2, and F2 showed normal temperature (Table 2). Respiration and heart rate were normal (Deem and Karesh 2002; Kreeger 1996) (Table 2).

General morphometry: M1 was the largest of all with a body length of 141 cm. F1 was the smallest with a body length of 103 cm (Table 3).

DISCUSSION

We found that Ketamine hydrochloride (@5 mg/kg body weight) and Xylazine hydrochloride (@1.5 mg/kg body weight) were effective and safe for the purpose of immobilisation of leopards for radio collaring studies. This drug combination has been used previously on leopards (Belsare and Athreya 2010; Jayaprakash *et al.* 2001), Mountain Lion *Puma concolor* (Logan *et al.* 1986), African Lion *Panthera leo* (Herbst *et al.* 1985), Tiger *Panthera tigris* (Goodrich *et al.* 2001; Seal *et al.* 1987), Snow Leopard *Panthera* (=*Uncia*) *uncia* (Oli 1997), Clouded Leopard *Neofelis nebulosa*, Leopard Cat *Prionailurus bengalensis*, and Asiatic Golden Cat *Pardofelis temminckii* (Grassman *et al.*

Table 3: Body measurements of the leopards

Animal ID	Estimated body weight (kg)	Actual body weight (kg)	Body length (cm)	Tail length (cm)	Foreleg (cm)	Hind leg (cm)	Neck girth (cm)	Chest girth (cm)
M1	65	63	141	86	80	28	48	84
F1	30	27	103	75	59.5	23	32	58
M2	50	46	121	89	70	27	39	70
F2	35	35	114.5	77.5	64	23.5	36	61

2004) and captive felids (Sontakke *et al.* 2009). Oli (1997) immobilised Snow Leopard in Nepal using Ketamine HCl and Xylazine HCl (ratio of 6:1) at an average dose of 7.3 mg/kg estimated body weight. Rettig and Divers (1986) advised using Xylazine at the dose of 1.1–2.2 mg per kg body weight for muscle relaxation along with ketamine at 11–12 mg/kg body weight. Logan *et al.* (1986) used a Ketamine-Xylazine mixture for immobilising wild Mountain Lion in cold climatic conditions for research purposes at the dose rate of 11 mg Ketamine and 1.8 mg Xylazine/kg estimated body weight. We found that the Ketamine-Xylazine drug combinations (ratio of 5:1.5) were satisfactory in inducing rapid and relatively smooth anaesthesia with reasonable recovery time in the leopards that we tranquilised.

In our study, the induction time seen was 3–6 minutes. No convulsion, vomiting or hypersalivation took place during and after the immobilization procedure. Mudappa and Chellam (2001) captured Brown Palm Civet *Paradoxurus jerdoni* using Xylazine and Ketamine, and two individuals vomited while recovering. Emesis was observed in a large male African Lion (Logan *et al.* 1986) that had consumed an entire Mule Deer *Odocoileus hemionus* fawn the previous night of tranquilisation. In leopard F1, the high temperature found was probably due to stress and wounds on her body.

Yohimbine was found to be effective in hastening the recovery from Ketamine-Xylazine anaesthesia in a dose-dependent manner in this study. A speedy recovery is advantageous in wild felids, especially in free-ranging animals and for research purposes. Yohimbine is a known potent alpha-two adrenergic antagonist and has been used as an antagonist for Xylazine-induced sedation and also in Ketamine-Xylazine anaesthesia in wild ungulates (Jessup *et al.* 1983; Sontakke *et al.* 2007). Studies in the domestic cat (Hsu and Lu 1984) and the Bengal Tiger (Seal *et al.* 1987) suggested that Yohimbine could hasten the recovery of Ketamine-Xylazine induced anaesthesia.

It was observed that the cages need to be immediately covered so that the animals do not see the humans. We used thin dark-coloured cotton bedsheets which were doused with water to keep the animal cool. We found that even while the cage was being moved by many people, the animal would remain quiet if it did not see people, otherwise, it became aggressive. We also tried to reduce noise levels while near the un-sedated animal. Even when sedated, we tried to work fast and quietly as these drugs do not completely block off the external stimuli to the animal (Deem 2004).

We concluded that the Ketamine and Xylazine anaesthesia @ 5 mg/kg and 1.5 mg/kg respectively was effective for proper immobilisation of leopards and that Yohimbine (0.14–0.17 mg/kg) can be used to hasten recovery from anaesthesia. We also found that it is relatively easier to deal with wild leopards if care is taken not to stress them with loud noises and visual stimulus of humans. Further studies using larger numbers of leopards may prove helpful and important in determining better drug dosage use in leopards.

Athreya *et al.* (in press) have documented that different predators can survive in human dominated landscapes or rural areas such as discussed in our study area. However, there are conditions that need to be present in the landscapes of rural areas to support them. Athreya *et al.* (in press) suggest that leopards in such landscapes use the cover of sugar cane and other tall crops as habitat, and prey on domestic dogs and livestock. Radio collaring animals helps in generating information on such animals to aid in mitigation measures where the conflict level is high. The results of this study would help in chemical restraint of such animals and it is recommended that similar protocol is followed to ensure the safety of the animals.

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STATUS OF JAPANESE QUAIL *COTURNIX JAPONICA* IN THE WILD IN INDIA AND LEGAL ASPECTS OF ITS EXISTENCE IN THE INDIAN POULTRY INDUSTRY

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In the Indian bird and poultry markets, the Japanese Quail *Coturnix japonica* is probably the most commonly traded Galliformes, apart from the domestic chicken. Apart from the normal coloration of birds similar to their wild counterparts, white, fawn, and pied mutations varieties are also sold in considerable numbers. However, its legal status in the trade has been questioned from time to time. In this paper, we discuss the ornithological and avicultural aspects of Japanese Quail with regard to its (wild) population status and the legal aspects of its occurrence in the Indian poultry industry in India.

Key words: Japanese Quail *Coturnix japonica*, legal status, farming, domestic bird, Indian poultry industry

INTRODUCTION

The status of wild Japanese Quail *Coturnix japonica* in India has been an issue of much debate and equal concern, especially since the last two years for the following reasons:

The species has recently been uplisted to Near Threatened in the IUCN Red List from its earlier status of Least Concern, as it is believed to have undergone a moderately rapid population decline due to hunting and shifts in agricultural practices (BirdLife International 2011; Rahmani 2012).

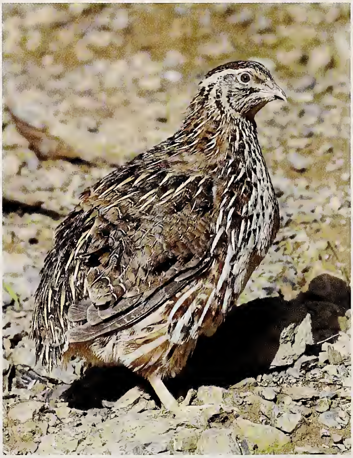

Fig. 1: Normal colouration of farm-bred Japanese Quail

In September 2011, the Ministry of Environment and Forests (Wildlife Division) (MoEF), Government of India issued an advisory* regarding the prohibition of farming of Japanese Quail, since it is listed in Schedule IV of the Wildlife (Protection) Act (WLPA), 1972 (Letter 1, Srivastava 2011). However, many quail breeding farms still 'legally' exist in several Indian states with prior licences in accordance to the MoEF earlier circular dated June 27, 1997 (Letter 2, in litt.).

The MoEF circular of September 22, 2011, has been stayed by the Madurai Bench of the Madras High Court on February 01, 2012 (Press Trust of India 2012). It is not known as to whether the order has been subsequently modified or not. However, on April 27, 2012, the MoEF issued a letter in response to the query raised in the Lok Sabha by Shri S.S. Ramansubbo,

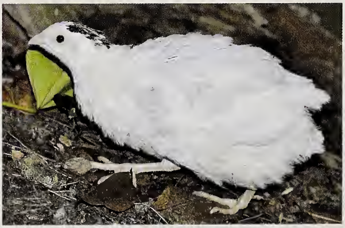

Fig. 2: Farm-bred white coloured Japanese Quail

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* The Ministry of Environment and Forest (MoEF) had not issued any gazette notification but only letters to concerned officers from time to time.

MP, clarifying the stand of the MoEF regarding "Need to renew licenses for Japanese Quail farming in the country" along with the question on livelihood issues (Letter 3, in litt.).

Further to this letter, on July 06, 2012, the MoEF again issued an advisory* on the subject of Japanese Quail farming stating "not to deny renewal of licences of existing units provided the license is not for an expanded capacity or a new unit" (Letter 4, in litt.).

Lastly, the legal status of the ongoing trade in Japanese Quail in India still remains somewhat unclear, and hence, there is a legal grey area in most cases of quail seizures. A basic question that most stakeholders have today is whether the sale and utilisation of domesticated Japanese Quail in various Indian bird and poultry markets is legal or illegal.

In this paper, we discuss the ornithological and avicultural aspects of Japanese Quail with regard to its (wild) population status in India and the legal issues of its occurrence in the Indian poultry industry. We make it clear that we do not endorse or oppose Japanese Quail farming in India, and suggest that any decision taken on this species in India be based on scientific facts (presented in this paper or available elsewhere).

STATUS OF JAPANESE QUAIL IN THE WILD IN INDIA

According to Rahmani (2012), the Japanese Quail is a purely migratory species in north-east India, in unknown numbers. As it is similar to the Grey Quail *Coturnix coturnix*, which is resident in India and with numbers augmented by winter migrants, many reported records of Japanese Quail from Assam and Manipur need further confirmation. Rasmussen and Anderton (2005) mention "Status uncertain in region ... Vagrant in winter to Bihar (one specimen), Assam (Dibrugarh), and Manipur Valley". Ali and Ripley (1983) write about this species "Winter visitor in small numbers to Assam south of Brahmaputra river. Birds collected in Manipur in winter are intergrades with the nominate race". Choudhury (2000), probably based on earlier records, reported it as an uncommon winter migrant to Assam. Similarly, Sathyakumar and Kalsi (2007) suggest that Japanese Quail is a rare winter visitor to Assam, south of Brahmaputra river, in small numbers.

The Japanese Quail has a wide distribution outside India. It breeds in east Asia, from north Mongolia, Russia, to China, Japan and the Korean peninsula, and winters in Indochina, Myanmar, and Bhutan (BirdLife International 2011). Grimmett *et al.* (1998) mention that this species probably breeds in Bhutan; however, according to McGowan (1994), the species is poorly known in Bhutan with lack of records, which is a cause of concern.

Based on the available Indian ornithological literature and other publications stating the general distribution of the species in India, there seem to be hardly any published sight records of this species in recent years. It is listed as distributed in India based on former ornithological records and specimens. It seems that there have been no recent sightings of the species in the wild by any ornithologist, and if any, they need to be published. The species, being a rare winter migrant, remains unknown and unseen to most Indian ornithologists throughout its presumed stay in India. Moreover, there are not many expert ornithologists in the region of its distribution in India.

THE CONTROVERSY OF JAPANESE QUAIL AVICULTURE IN INDIA

Given that the Japanese Quail is listed in Schedule IV of the WLPA and that the MoEF had granted permissions for setting up quail farms, there is considerable confusion on the subject. From time to time, seizures are made by enforcement agencies, and consequently, there has been a lot of hue and cry from certain sections demanding a total ban on its trade. It is a common perception that the seized Japanese Quails and their eggs are obtained from the wild – even though no ornithologist, naturalist, or animal activist has seen the species in the wild in recent times. It is extremely difficult to presume that the large numbers of seized birds that had come to the market for sale are from the wild, e.g., the case of seizure of quail eggs from Shivaji Market in Bengaluru (Times of India 2008).

Another valid query against the seizures is whether the Indian poultry or bird traders have more knowledge of the distribution, seasonality, ecology, and habits of the species than ornithologists/Forest Department to be able to obtain them in sufficient numbers, and also have facilities to transport/smuggle them from their known distributional range in NE India to the markets in southern India, and additionally, sell the eggs at a low price (Rs. 4/egg) (Times of India 2008).

JAPANESE QUAIL IN THE INDIAN POULTRY INDUSTRY

In captivity, the Japanese Quail is a worldwide well-known aviculture subject and a poultry bird, and listed in the list of domesticated animals (Japanese Quail n.d.**). It has been selectively bred in captivity for meat and egg productivity in Japan for several centuries (Yamashina 1961). The species has been domesticated since the 12th century CE in Japan, where it was kept as a song bird. In China, the history of quail domestication goes back at least 1,500 years (Chang *et al.* 2009). The domesticated Japanese Quail was first introduced to Europe (France and Italy) in the 1950s

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**n.d.: no date

(Sanchez-Donoso *et al.* 2012). Robbins (1981), the founder member of The Quail Group of the World Pheasant Association, in his book QUAIL – THEIR BREEDING AND MANAGEMENT commented on the Japanese Quail "Now hybrids in many forms, therefore, true form difficult to establish. Produced in large numbers for the table." Ali and Ripley (1983) state "Has been domesticated in Japan as a table delicacy, for its meat and eggs, within the last 50 years or so by selection from quails formerly kept for song. Quail-breeding is now a flourishing minor industry. The birds are kept perpetually under artificial light like battery hens and with special feeding and care, good females lay from 250 to 300 eggs per year. They begin to lay when only 35–60 days old, and continue non-stop for 8–12 months thereafter."

The Central Avian Research Institute (CARI), an institute of Indian Council of Agricultural Research, has been pioneering quail research and propagating quail farming as their mandate since 1974. According to their Director, Dr. R.P. Singh (pers. comm. 2012), eggs were first imported into India in 1974 from the University of California from where most of the Indian stock of farmed quails originates today. CARI has taken a lead to develop a number of new strains of egg and meat type quails by utilising imported founder stock. Parent stock for broiler quail lines, such as Cari Uttam, Cari Ujjawal, Cari Sweta, Cari Brown, and Cari Pearl for poultry farmers are now easily available at a price ranging between Rs. 15–30 each for an age group between 1–4 weeks (Indian Council of Agricultural research n.d.; Neel n.d.).

TRAFFIC India/WWF-India has been conducting a countrywide survey on illegal bird trapping and trade since 1994, covering the entire country with more than 300 field visits carried by the first author. Though a number of wild caught quail species, such as Common Quail *Coturnix coturnix*, Rain Quail *Coturnix chinensis*, and Jungle Bush-Quail *Perdicula asiatica* were recorded and traded in bulk in Indian bird trade markets or poultry markets for food, not a single wild caught Japanese Quail specimen was recorded, and all the Japanese Quails recorded on sale (more than 20,000 birds) were of domestic origin (Ahmed 1997, 1999, 2000, 2002, 2004, 2012b, in prep.). However, during market surveys, it was observed that wild caught quails and francolins of various species were sometimes fraudulently sold under the garb of domesticated quails (Ahmed 1999). The seizure of domesticated quails on the presumption that they are wild birds causes substantial loss to traders.

Until 2011, before the MoEF notification came into force, the National Bank for Agriculture and Rural Development (NABARD) provided financial assistance to beneficiaries willing to take up quail farming and encouraged such livelihood options for farmers (Pinjarkar 2011).

DIFFERENTIATING DOMESTIC AND WILD JAPANESE QUAIL

It is essential to know how to differentiate a domesticated quail from its wild counterparts, especially in this context, as evidence in court cases. In the case of domesticated species, Sanchez-Donoso *et al.* (2012) state "As a result of the selection for life in captivity, these birds have lost their migratory restlessness, show some reluctance to move and fly, and have lower anti-predatory instinct." A domesticated Japanese Quail without its flight feather clipped will not fly even if taken out of the cage, and in fact, will move around calmly and be unafraid of humans. Conversely, a wild caught quail freed from the cage will immediately try to fly or take to shelter if its flight feathers are clipped. The first author's observations over the years suggest that domesticated quails will have no injury marks on their head, face, and other regions caused by banging into the cage bars while attempting to free themselves, a behaviour quite commonly seen in wild caught quails when initially introduced into captivity. In most cases, wild caught quails when put in cages will have signs of head injury, and may have all flight feathers plucked by traders to prevent injuries and escapes. Most wild caught quails will be in an emaciated condition and have to be force fed with grain, and their droppings are not semi-liquid. The faeces of domesticated quails fed largely on commercial poultry feeds are quite different from that of their wild counterparts on close examination. Moreover, wild caught quails do not generally accept artificial poultry feed in the initial days of captivity.

Comparative studies on domesticated and wild Japanese Quail by Chang *et al.* (2009) revealed differences in morphological pattern and ecological behaviour, along with significant differences between domestic and wild birds in reproductive traits, involving mating, fertility rate, and hatching rates of fertilised eggs. Wild Japanese Quail are seasonal breeding birds and usually breed between May and October, whereas domesticated quails lay eggs all year round. According to Yamashina (1961), domesticated quails show a high laying efficiency of 80% (250–300 eggs during the first year). The easy upkeep and high yield has made quail farming a lucrative option for farmers.

LEGAL ISSUES OF WILD AND DOMESTIC JAPANESE QUAILS IN INDIA

All species of quails found in the wild in India, except for the Himalayan (Mountain) Quail *Ophrysia superciliosa,* are collectively listed without individual species name in Schedule IV of the Indian Wildlife (Protection) Act, 1972 (Anon 2009) under the family Quails (Phasianidae). The

Himalayan Quail is individually named and included in Schedule I, Part III of the WLPA. As the Japanese Quail is listed in the Indian avifauna checklist (e.g., Ali and Ripley 1983), it automatically gets legal protection under the WLPA, which when amended in 1990–91, banned the trade in all Indian birds.

The legal status of the trade in Japanese Quail in India remains somewhat ambiguous and has been questioned from time to time by various state governments, animal activists, and enforcement agencies. In 1997, the MoEF wrote to the Forest Secretaries and Chief Wildlife Wardens of all states deciding to delegate the power of issuing licences for Japanese Quail hatcheries to the officer of the Department of Animal Husbandry, Government of India, not below the rank of Assistant Livestock Officer and for officers of the state Animal Husbandry Department not below the rank of Veterinary Assistant Surgeon. States were accordingly requested to issue necessary notifications under the WLPA empowering such officials to issue licences under intimation to the MoEF (Letter 1 in litt.). After this MoEF notification, several facilities breeding and shops selling Japanese Quail have come up after obtaining licences across the country.

Despite this, farm bred Japanese Quail get seized from time to time in various states since quails are listed in Schedule IV of the WLPA. The Japanese Quail bred and sold in farms/shops are not only of the wild coloration, but also white (Figs 1 and 2), fawn, and pied. Some poultry breeders and bird dealers tried to breed and sell more colour mutation quails rather than normal coloration birds to help enforcement and the general public to understand the difference between wild and domesticated birds. Universities such as the Guru Angad Dev Veterinary and Animal Science University in Punjab (Guru Angad Dev Veterinary and Animal Science University n.d.), Virtual University for Agricultural Trade, Department of Agriculture, Government of Kerala and other institutions (Poultry Quails n.d.) tried to develop a more hardy and white-coloured strain of Japanese Quail. These projects were challenged by animal activists suggesting that they were illegal as they did not have permission from the Committee on Animal Experimentation (Dugar 2002).

As the Japanese Quail continues to be listed in Schedule IV of the WLPA, hunting, capturing, killing or trade in such birds clearly appears to be a violation of the WLPA. The farm bred quails are also "Captive Animals" as per Sec 2(5) of the WLPA and liable to attract the provisions against hunting as defined in Sec 2(16). On receiving repeated representations about the violation of WLPA from several quarters, the MoEF on September 22, 2011, issued another letter in this regard (Letter 2, in litt.) requesting states/UTs not to issue any new licences for farming of Japanese Quail and also not to issue any permission for expansion or augmentation of existing facilities. However, this letter is silent on the crucial point of the status of existing farms and quails bred and sold by them, even while specifying that by virtue of the Japanese Quail being included under Schedule IV of the WLPA, such species cannot be killed/hunted or captured. This notification has made the enforcement agencies and various stakeholders quite unclear as to what needs to be done about birds seen in the markets. Are they from licensed farms with permissions? If not, can the quails in markets be seized? Can a common man buy them not violating the law of the land? Can restaurants serve it?

In our view, the following options need to be closely examined and debated among policy makers who should necessarily include ornithologists, aviculturists, government officials, and animal activists before a clear and implementable decision can be taken:

1. **The Japanese Quail continues to be listed under the WLPA and its farming is completely prohibited and no breeding or sale allowed**: In this case, what happens to the existing birds that are mutations, hybrids and purely domesticated (not just captive-bred) ones? Should domestic populations be completely restricted from breeding or should they be culled once and for all, as they may be unfit to be released in the wild? There is a need to also look into how many such legal farms and institutions propagating quail farming actually exist in various Indian states. What is the actual parent stock and how many offsprings are produced each year?
2. **The Japanese Quail be taken out of the WLPA as there is hardly any recent evidence of this species in the wild within Indian limits**: In this case, a team of competent ornithologists need to survey its reported wintering area in India and confirm its population status. As it is most likely to be a winter vagrant to India, it may not in all likelihood be a true claim that wild caught Japanese Quails are collected from the wild and are traded. However, one needs to be vigilant as the Japanese Quail looks quite similar to Common Quail.
3. **The Japanese Quail continues to be listed under the WLPA but a specific provision permitting captive breeding of domesticated strains and its sale is made in the WLPA as per Sec. 11 and 12**: The problem clearly is that of an administrative order, permitting something that is not within the provisions of the WLPA. A comparative example would be the case of Indian Peafowl *Pavo cristatus*, where, while the species is listed in Schedule I, the domestic trade in peacock tail feathers and products is permitted (Ahmed 2008) by a specific mention to this being made in the WLPA itself, and not by any separate notification.

4. **In a manner similar to the Blue Rock Pigeon (*Columba livia*) that is excluded from Pigeons (Columbidae) list in the Schedule IV, the Japanese Quail can be excluded from the WLPA by simply stating:** Quails (Phasianidae) except the Japanese Quail (*Coturnix japonica*) in the Schedule IV listing.

Similarly two more Indian bird species, namely the Red Junglefowl *Gallus gallus* (resident) and Mallard *Anas platyrhynchos* (winter visitor) are ideal avian species for comparison with the Japanese Quail issue. Almost all varieties of the domestic chicken *Gallus gallus domesticus* and duck *Anas platyrhynchos domesticus* have been derived from the wild Red Junglefowl and Mallard, and are farmed and traded throughout India. Similarly, the domesticated variety of the Japanese Quail can be named *Coturnix japonica domesticus*, which can then be allowed for trading, and this will keep the integrity of their wild counterparts safe. Additionally, since there is no ban on the domestic sale of any exotic animal within India and the farming and selling of domestic Turkey *Meleagris gallopavo*, domestic Guineafowl *Numida meleagris*, Emu *Dromaius novaehollandiae*, and rabbit is not questioned, the domesticated Japanese Quail may very well fit this group.

CONCLUSION

Awareness about the illegal bird trade and curtailing the demand for wild birds as pets, food, release, black magic, sport, and medicinal use has been a growing concern for many enforcement agencies, NGOs, and individuals (Ahmed 2004, 2010). However, there is also a need to understand the fact that there are three categories of birds in trade.

1. One group that has species that are caught from the wild, which are either extremely difficult to breed in captive conditions, or available in bulk from the wild at negligible cost and have a high market demand. For instance the munias (*Lonchura* spp.) are difficult to breed in captivity, but are available from the wild in thousands.

2. The second category is of birds that can be captive bred in a closed set-up, but the species has not been fully domesticated. Individuals from wild-caught are more in the trade and few from captive-bred sources. For instance, most species of macaws and cockatoos are easier to catch from the wild than to obtain from a captive-bred source.

3. The last category is of birds of pure domestic origin. Birds that have been domesticated, crossbred, and bred in thousands worldwide over several generations and years and now have many colour mutations. Their wild counterparts are more expensive and difficult to acquire in comparison to the farmed source. For instance, the Budgerigar (*Melopsittacus undulatus*) and Japanese Quail.

The trade in wild animal and birds, discussed under the first category, should be totally banned and anyone doing it should be severely punished in any country, state or region. Permitting the second category of captive-bred birds for any trade purpose will vary from country to country, depending on the country's expertise, infrastructure, technology, and its administrative ability to identify a captive-bred bird from a wild-sourced one through closed ringing or micro-chipping. Trade in the second category of birds cannot be recommended in India at this moment, as we still lack the resources and expertise to undertake such an exercise.

Monitored trade in the third category of domesticated mutant/crossbred bird varieties can actually help conserve wild birds by taking away the pressure from their wild counterparts. Such trade as in farmed Japanese Quail could be allowed, albeit with the required safeguards to prevent wild counterparts being sold fraudulently in the garb of exotics or domestics (Ahmed 1999).

We also need to take into consideration that more than 5,000 families from traditional bird trapping communities still depend on the wild bird trade in India, including quails and partridges (Ahmed 2012a). Studies on wild bird trafficking also show that if domestic birds are 'wrongly' seized, traders and trappers resort to selling wild birds, which require less investment compared to farmed sources (Ahmed 2012b). With the high demand for quail meat in India, there is a need to permit the sale of the meat of domesticated quail (a practice gaining more prominence in Indian birds and poultry markets since the past decade), as an ideal alternative to wild birds traded for meat. We need to remember that the trade in wild bird meat goes totally undocumented or unnoticed, as they are sold from door to door. In this kind of a situation, our policies concerning Japanese Quail need to be re-examined for clarity of law and rules to be implemented to conserve wild Indian quails in general.

With the enigmatic Himalayan Quail, a Critically Endangered endemic Indian species being extinct and another endemic species of north-east India, the Manipur Bush-quail (*Perdicula manipurensis*), listed as Vulnerable and with one or two sightings since its last confirmed record in the early 1930s (Rahmani 2012), we need to prioritise our conservation efforts in a more focused manner and accept the reality of the domesticated Japanese Quail presence in India, rather than take a sentimental approach, especially since the farming of Japanese Quail could lessen, if not curtail, the demand for wild quails and partridges.

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(**Note**: The views expressed in this article are solely of the authors and do not necessarily reflect those of any organisation or institution).

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WILDLIFE HUNTING PATTERNS, TECHNIQUES, AND PROFILE OF HUNTERS IN AND AROUND PERIYAR TIGER RESERVE

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Hunting is believed to threaten the survival of many important wildlife species in India. However, few studies have documented this threat because hunting is prohibited under the Indian law and is therefore conducted covertly. In this study, we interviewed community members of a conservation project, who were currently or had previously hunted wildlife in and around Periyar Tiger Reserve, southern India. We documented the species hunted, hunting methods, and the profile of hunters to know the demographic and socio-economic drivers of illegal hunting. Of the 183 respondents, 32.8% had previously hunted and 7.1% were still engaged in hunting. Of the 20 different methods identified, hunters mainly used guns (33.4%), scavenged kills (30.0%), or set snares (26.7%). From 19 mammal, 12 bird and/or 3 reptile species hunted, the most commonly taken of any species were medium to large-bodied mammals (68.5%), especially Sambar *Rusa unicolor* (56.7%) and Wild Pig *Sus scrofa* (45.0%). These were mostly for household consumption or local trade. The respondents were more likely to hunt if male, married, and with a primary school education or none. For the Periyar Tiger Reserve, projects offering access to higher education, promotion of alternative protein use, and stricter law enforcement should strengthen efforts to reduce wildlife hunting

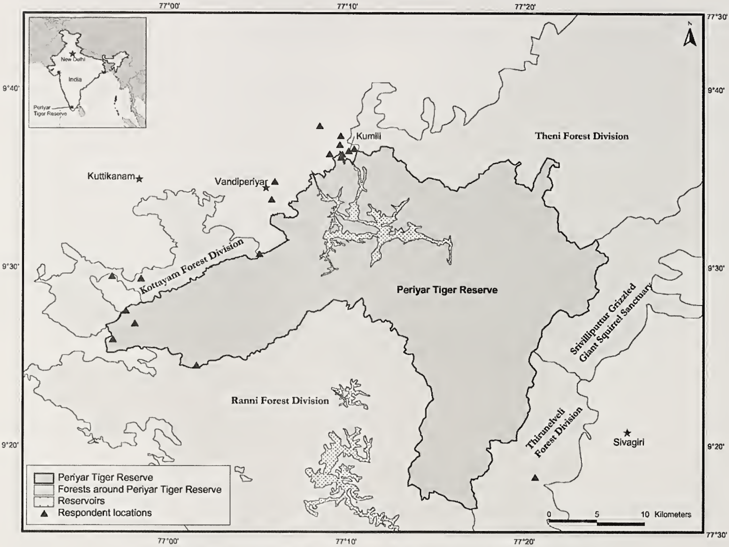
Key words: hunting, community-based conservation, mammals, law enforcement, Periyar Tiger Reserve

INTRODUCTION

The extraction of wild animal and plant species for subsistence and trade is widespread across the tropics and most often conducted at unsustainable levels (Bennett *et al.* 2002). Various strategies have been employed to tackle unsustainable, and often illegal, hunting of wildlife, such as increasing law enforcement effort and reducing consumer demand. Nevertheless, whether inside or outside of protected areas, hunting remains one of the principal causes of wildlife population declines (Bennett 2011; Redford 1992).

Data on spatio-temporal hunting patterns, capture techniques, species taken and hunter profiles are important sources of information for enabling a better understanding of the demographic and socio-economic drivers of illegal hunting (Milner-Gulland *et al.* 2003). These data also help conservation managers and field staff to better detect illegal hunting locations and deliver more appropriate community outreach programs that would mitigate the impacts of hunting (Eliason 1999). Such data and their patterns are well-documented for Latin America, Africa, and Southeast Asia, and tend to depict medium to large-bodied mammals as being the preferred target species and which are harvested at unsustainable levels (Bodmer *et al.* 1997; Fa *et al.* 2002; Milner-Gulland *et al.* 2003). However, for South Asia, especially India, which has some of the highest abundances and diversity of these mammals, the availability of scientific literature on illegal hunting is relatively poor and has been highlighted as a priority area for conservation research (Velho *et al.* 2012)

Hunting in India has existed since the early ages (3000 BCE), but precipitated during the Mughal rule (1526–1858 CE) and colonial periods (1757–1947 CE) (Divyabhanusinh 1999; Rangarajan 2001), and continued in one form or another after the leaving of the British, till the passing of the Wildlife (Protection) Act in 1972, which banned hunting of all forms of wildlife in India. Nevertheless, illicit hunting still continues for recreation, subsistence, trade, in retaliation to conflicts with wildlife, and as part of traditional ceremonies, especially of tribals (Aiyadurai *et al.* 2010; Datta 2007; Madhusudan and Karanth 2002). The hunters themselves range from indigenous forest dwelling communities to villagers at the forest edge, to government, army officials, and politicians (Aiyadurai 2007; Bhatnagar *et al.* 2006; Chandi 2006; Datta 2007; Hilaluddin and Ghose 2005; Kaul *et al.* 2004; Madhusudan and Karanth 2002; Mishra *et al.* 2006). Presently, hunting is considered to be more prevalent in the north-eastern states due to strong and long-standing customary traditions that are culturally similar to Southeast Asia (Datta *et al.* 2008; Aiyadurai *et al.* 2010). Studies from elsewhere in India, especially from the wildlife-rich Western Ghats, are relatively few even though hunting is documented as a serious threat to its wildlife (Kumara and Singh 2004; Madhusudan and Karanth 2002; Sukumar *et al.* 1998). Furthermore, hunting pattern characteristics are only known from a few studies (Aiyadurai *et al.* 2010; Madhusudan and Karanth


77°00'
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New Delhi
India
Periyar Tiger Reserve
Kumili
Theni Forest Division
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Vandiperiyar
Kottayam Forest Division
Periyar Tiger Reserve
Srivilliputtur Grizzled Giant Squirrel Sanctuary
Ranni Forest Division
Thirunelveli Forest Division
Sivagiri
0
5
10 Kilometers
Periyar Tiger Reserve
Forests around Periyar Tiger Reserve
Reservoirs
Respondent locations

Fig. 1: Periyar Tiger Reserve, its adjoining forest divisions and locations of respondents

2002), and for such a vast, culturally diverse, and hugely populated country these would be woefully insufficient as regional studies are unlikely to apply to other states or regions.

In this study, we documented the hunting patterns in and around one of India's flagship wildlife protected areas, the Periyar Tiger Reserve, investigating the prevalence of hunting, hunting methods, hunted species, and the hunters' demographic and socio-economic profile.

STUDY AREA

The 777 sq. km Periyar Tiger Reserve (PTR), in the southern Indian state of Kerala, was established in 1950 to conserve endangered wildlife, particularly the Asian Elephant (*Elephas maximus*), Tiger (*Panthera tigris*) and its prey such as Gaur (*Bos gaurus*) and Sambar (*Rusa unicolor*). The Reserve is surrounded by two forest divisions and one wildlife sanctuary forming nearly 2,000 sq. km of contiguous forest habitat, though varying in degree of status and protection (Fig. 1). These forests consist of a diverse array of vegetation types, including tropical evergreen forest, moist and dry deciduous forest, and high elevation grasslands (Kerala Forest Department 2001). Other important wildlife species found in this area include Leopard (*Panthera pardus*), Dhole (*Cuon alpinus*), Sloth Bear (*Melursus ursinus*), Nilgiri Tahr (*Nilgiritragus hylocrius*), Lion-Tailed Macaque (*Macaca silenus*), Nilgiri Langur (*Trachypithecus johnii*), and Great Pied Hornbill (*Buceros bicornis*).

PTR is managed by the Kerala State Forest Department that carries out law enforcement activities, through permanent and semi-permanent staff, to primarily prevent wildlife poaching, illegal timber and forest produce harvesting, and forest fires. Regular foot patrols and strategically located anti-poaching camps are the most commonly employed threat mitigation strategies.

An estimated 225,000 people live within 2 km of the PTR boundary (Kerala Forest Department 2001), including forest-dwelling communities who were relocated to the periphery of the Reserve during the 1890s and 1940s (Arun *et al.* 2001; Gurukkal 2003; Kerala Forest Department 2002).

The Reserve has a 90 km inter-state boundary with Tamil Nadu, hence a large number of migrants belonging to distinct ethnic backgrounds and traditions have settled around it. These communities depend, to varying degrees, directly and indirectly on the natural resources of PTR, including through harvesting of non-timber forest products, wildlife poaching, timber smuggling, livestock grazing, and narcotics cultivation, and through legally sanctioned tourism and pilgrimage management (World Bank 1996). Much of the land surrounding PTR is intensively farmed, mostly as cash crop plantations for tea, rubber, cardamom, and coffee.

METHODS

From May to July 2006, a structured questionnaire survey was administered to people living in and around the PTR, with the primary aim of assessing local attitudes towards wildlife conservation and participation in an US$6.0 million Integrated Conservation and Development Project (ICDP) that was implemented from 1996 to 2004 (Gubbi *et al.* 2009). From this questionnaire survey database, 183 randomly selected respondents were interviewed and their background information collected for eight demographic factors (gender, age, religion, whether local or migrant, forest dwelling or non-forest dwelling, household size, whether a nuclear or extended family unit, and the highest level of formal education in the family) and five socio-economic factors (occupation, land ownership, issues related to human-wildlife conflict, dependency on forest products, and ICDP participation). Distance of a respondent's household from the forest boundary was also measured using digitised topographic maps.

Interviews were conducted through a local informant network and trusted community members (acting as interpreters in Malayalam and Tamil, where needed) who were aware of the local issues. Here, a section from the unpublished dataset from the questionnaire survey that focussed on hunting patterns is used. We were able to obtain feedback to questions that may normally be considered sensitive because the survey team members were selected for their strong social skills and high acceptance amongst the local communities (being from the community or having spent many years successfully working with the community). All interviews were conducted with the full willingness of the respondents, who were assured of full anonymity and on the assurance that the data was being collected for scientific research for an international university (Kent) and not for the Kerala Forest Department.

Through the questionnaire, respondents were asked whether they had previously (within the past 10 years) or were currently hunting wildlife, and if so, the species targeted and the trapping techniques used. For respondents unsure of the species name, pictures from field guides were shown (Daniel 2002; Grimmett *et al.* 1999; Menon 2003). To investigate hunting preference, species were classified by taxa (mammal, bird, or herpetofauna) and for the mammal species by their body mass (small <10 kg, medium 10–100 kg, or large >100 kg). Mean species body mass was obtained from several sources (Ali and Ripley 1987; Daniel 2002; Menon 2003; Prater 1971). The reason for hunting a species was also recorded (consumption for food, consumption as medicine, locally sold or kept as a pet). The IUCN Red List and endemic status of each species was also assigned (IUCN 2011).

The main occupation of respondents was categorised as hunter, collector of forest produce (non-timber forest product, fuelwood, thatch grass harvesting, or timber and sandalwood smuggling), self employed (small business or taxi driver), and labourer (agricultural or small non-agricultural business).

The respondents consisted of various religious groups, including Hindu, Muslim, Christian, Ezhava, Nair, Pallar, and others. Mannan, Paliyan, Oorali, Malampandaram, and Maleariyas were the former forest dwelling communities. Currently, Malampandaram is the only group that are partially nomadic and are largely dependent on natural resources for both food and cash incomes. All the respondents were residing in or around the forests of the PTR.

All questionnaire data were imported into SPSS v.14.0 statistical software (SPSS Inc., Chicago, IL, USA). After controlling for collinearity between independent variables, binary logistic regression analyses were performed to determine which variables, individually or in combination, best explained the socio-economic and demographic factors of those who had hunted medium to large bodied mammals. These candidate models were ranked by their delta Akaike Information Criterion values adjusted for small sample sizes (AICc) and by their Akaike weights (*wi*) (Burnham and Anderson 2002). For the final, top-ranked model, its performance was evaluated by calculating the area under the curve of the receiver operating characteristics (ROC) plot (Pearce and Ferrier 2000).

RESULTS

Hunting species preference and techniques

A total of 34 species were recorded to be previously or currently hunted; 19 mammal species (6 small, 9 medium, and 4 of large body size), 12 bird species and 3 reptile species (Table 1). Most of the respondents (90%) hunted mammals, in comparison to birds (66.7%) and reptiles (45%). Ungulates were the most commonly hunted mammal (31.5%), especially Sambar (56.7%), and Wild Pig (45.0%). Only two respondents

Table 1: Wildlife species hunted in Periyar Tiger Reserve based on reports of respondents

Species	Hunting technique	Use	Red List status	Respondents who hunted (%)$^{+}$	Body mass (kg)	Major ecological role(s) of the hunted species
Mammals				**90.0**		
Sambar *Rusa unicolor*	Gun, scavenging wild dog kills	Food – SU, SA	VU	56.7	Large	Seed disperser (Kitamura *et al.* 2002)
Wild Pig *Sus scrofa*	Gun, snare, explosives in bait, scavenging wild dog kills chase and catch	Food – SU, SA	LC	45.0	Medium	Seed disperser Seed predator (Ickes *et al.* 2001)
Mouse Deer *Moschiola meminna*	Snare, blind with torch and kill with stick, hunting dogs	Food – SU	LC	38.3	Small	Seed disperser and predator (Devy 2006)
Barking Deer *Muntiacus muntjak*	Gun, snare	Food – SU, SA	LC	30.0	Medium	Seed disperser (Kitamura *et al.* 2002)
Indian Giant Flying Squirrel *Petaurista philippensis*	Smoke out from roosting cavities or poke into roosting cavities using a sharp stick	Food – SU	LC	30.0	Small	Seed disperser and pollinator (Fujita and Tuttle 1991)
Gaur *Bos gaurus*	Gun	Food – SU, SA	VU	26.7	Large	-
Indian Giant Squirrel *Ratufa indica*	Gun, picking young ones from nest	Food – SU	LC	23.3	Small	Seed predator (Kitumara *et al.* 2002)
Nilgiri Langur *Trachypithecus johnii*	Gun	Food, MED – SU, SA	VU	13.3	Medium	Seed predator (Devy 2006)
Black-naped Hare *Lepus nigricollis*	Snare	Food – SU, SA	LC	13.3	Small	-
Nilgiri Tahr *Nilgiritragus hylocrius*	Circle the group and scare an individual down to a ditch	Food – SU, SA	EN	5.0	Medium	-
Indian Crested Porcupine *Hystrix indica*	Hunting dogs	Food – SU	LC	3.3	Medium	Seed predator (Ganesh & Davidar, 2005)
Indian Flying Fox *Pteropus giganteus*	Net, thorns stuck on branches	Food – SU	LC	3.3	Small	Long distance seed disperser (Corlett 1998, David *et al.* 2011)
Leopard *Panthera pardus*	Gun	Trade – SA	LC	3.3	Medium	Predator
Tufted Grey Langur *Semnopithecus priam*	Hunting dogs	Food – SU	NT	3.3	Medium	Seed disperser (Corlett 1998)
Indian Elephant *Elephas maximus*	Gun	Trade – SA	EN	1.7	Large	Long-distance seed disperser (Corlett1998; Kitamura *et al.* 2002)
Sloth Bear *Melursus ursinus*	Gun	Food - SU	VU	1.7	Medium	Large seed disperser (Corlett 1998)
Common Otter *Lutra lutra*	Caught in fishing nets	Food – SU	NT	1.7	Small	
Bonnet Macaque *Macaca radiata*	Gun	Food – SU	LC	1.7	Small	Seed disperser, Seed predator

Table 1: Wildlife species hunted in Periyar Tiger Reserve based on reports of respondents (*contd.*)

Species	Hunting technique	Use	Red List status	Respondents who hunted (%)$^{+}$	Body mass (kg)	Major ecological role(s) of the hunted species
						(Corlett 1998; David *et al.* 2011)
Indian Pangolin *Manis crassicaudata*	Hunting dogs	Food - SU	NT	1.7	Small	-
Reptiles				45.0		
Indian Oval-grain Lizard (Monitor Lizard) *Varanus flavescens*	Chased and caught or killed with stick, with hunting dogs, stoning.	Food – SU, SA	LC	35.0	Small	-
Indian Pond Terrapin *Melanochelys trijuga*	Opportunistic picking, Caught in fishing nets, hunting dogs					
Indian Star Tortoise *Geochelone elegans*		Food – SU		40.0	Small	-
Birds				66.7		
Grey Junglefowl *Gallus sonneratii*	Snare, trap, picking eggs from nests	Food – SU	LC	55.0	Small	-
Malabar Grey Hornbill *Ocyceros griseus*	Catapult, gun	Food – SU	LC	13.3	Small	Seed disperser (Kitamura *et al.* 2008)
Green Imperial-Pigeon *Ducula aenea*	Gun	Food – SU	LC	5.0	Small	Seed disperser (Kitamura *et al.*2006)
Blossom- headed Parakeet* *Psittacula roseata*	Catapult	Pet – SU	LC	4.4	Small	Seed predator (Ali and Ripley 1987)
Great Pied Hornbill *Buceros bicornis*	Collecting young ones and eggs from nests	Food – SU	NT	3.3	Small	Seed disperser (Kitamura *et al.* 2002; 2008)
Malabar Parakeet* *Psittacula columboides*	Catapult, stoning	Food and Pet – SU	LC	3.3	Small	Seed predator (Ali and Ripley 1987)
Lesser Hill-Myna *Gracula indica*	Catapult, stoning	Pet – SU	LC	1.7	Small	-
Common Myna* *Acridotheres tristis*	Catapult, stoning	Food, pet – SU	LC	1.7	Small	Seed disperser (David *et al.* 2011)
Coucals* *Centropus sinensis* and *C. bengalensis*	Catapult, stoning	Food and MED – SU, SA	LC	1.7	Small	Predator (Ali and Ripley 1987)
Barbets* *Megalaima* spp.	Catapult, stoning	Sport – SU		1.7	Small	(David *et al.* 2011)
Sunbirds* *Nectarinia* spp.	Catapult, stoning	Sport – SU		1.7	Small	Pollinator (Ali and Ripley 1987)
Bulbuls* *Pycnonotus* spp. and *Iole indica*	Catapult, stoning	Sport – SU		1.7	Small	Seed disperser (Kitamura *et al.* 2002; David *et al.* 2011)

SU – Self use, SA – Sale, MED – Medicinal use

EN – Endangered, NT – Near Threatened, VU – Vulnerable, LC – Least Concern

Category of body mass: Small – <10 kg, Medium – 10–100 kg, Large – >100 kg

*caught as pets; $^{+}$cumulative totals will exceed 100% as most respondents hunted more than one species reported hunting leopard and elephant, for their body parts (pelt and ivory, respectively), and both were being prosecuted at the time of interview. The Red List threat status of the reported hunted species included three Endangered, four Vulnerable and two Near Threatened, with the remaining (25) being Least Concern. Nilgiri Langur and Nilgiri Tahr were the two endemic species reported to be hunted.

A total of 20 different hunting methods were reported and these were mostly (85%) traditional techniques (snares, scavenging dhole kills, hunting dogs, smoking from roosting cavities, etc.). Some (36.7%) respondents used modern hunting methods (guns, explosive baits, and blinding animals with a torch) for capturing high meat-yielding species (e.g. Gaur, Sambar, Wild Pig, Nilgiri Langur, Mouse Deer, Barking Deer, and Sloth Bear).

Hunter characteristics/profile

Of the 183 respondents, 32.8% had hunted wildlife species in the past and a few (7.1%) were currently involved in hunting, but the majority (60.1%) had never hunted. Of the respondents who reported to have hunted, most were male (83.3%), with 1.7% of the respondents in the age group of 18–25 years, 30% were 26–35 years, 33.3% were 36–45 years, 20% were 46–55, and 15% were above 55 years. Respondents from older age groups (26 and above) formed the majority (98.3%) of the hunters.

Both forest dwelling (60%) and non-forest dwelling (40%) respondents reported to have hunted in the past, with 62.7% being locals (from within the state) and 37.3% migrants who or whose parents had moved into this area, mostly from the neighbouring state of Tamil Nadu, in search of employment. Agricultural land was owned by 50% of the hunter respondents. Of the 60 respondents, 20% had no education, 45% had completed primary education, 33.3% had high school education, and only 1.7% had attained a tertiary level of education.

The respondents resided at a mean distance of 1.2 ±1.86 km (±SD) from the forest boundary. There was a clear difference between the sexes as only 16.7% of those involved in hunting (n=60) were women, and these were mostly involved in the collection of eggs from bird nests. Of these, only a few (5.6%) reported hunting methods using hunting dogs, catapults, and taking meat from Dhole (*Cuon alpinus*) kills. Only one female respondent reported to be currently active in hunting, whereas 21.7% of the men were still active.

Investigating the factors that best explained the characteristics of those previously involved in hunting, revealed a significant relationship with five factors (main occupation, gender, education, religion, and family type; Table 2, Model 1.1). Respondents were more likely to hunt if male, married, and with no formal education or with primary school education. Those working primarily as labourers were less likely to hunt. There was no effect from secondary occupation, age, household size, ownership of land, area of land owned and participation in the ICDP. Analysing the combination of factors that best explained the profile of an active hunter (n=13) was not possible due to the small sample size, and so this study makes the assumption that hunting patterns were similar to those that had previously hunted.

DISCUSSION

Our study provides the first insights into wildlife hunting patterns in and around the PTR, and it also responds to the recent call for quantitative studies of hunting patterns in India (Velho *et al.* 2012). The results were encouraging in that whilst hunting was prevalent in the past, with 32.8% of the respondents having previously hunted, it is less common today, with only 7.1% hunting. Nevertheless, although wildlife harvest levels were not recorded in this study, the

Table 2: Logistic regression models that best explained the characteristics of respondents who had hunted medium to large-bodied mammals in the past

Model	2log likelihood	K	ΔAIC	w_i	r^2
1.1 occupation+gender+education+religion+family*	40.09	6	0.00	0.665	0.709
1.2 occupation+gender+religion+family	44.64	5	2.55	0.186	0.671
1.3 occupation+gender+education+religion	46.32	5	4.24	0.080	0.657
1.4 occupation+religion+education	48.72	4	4.63	0.066	0.636
1.5 occupation+religion+gender	52.77	5	10.69	0.003	0.601

*ROC±S.E. = 0.977±0.01, indicating a good model fit widespread use of guns in PTR and unsustainable hunting patterns identified from elsewhere in India offer a cautionary note for the future of PTR's endangered mammal populations.

A hunting preference for larger-bodied wildlife species in PTR, particularly high yielding meat species (e.g. Sambar, Wild Pig, and Gaur), is consistent with other studies in the Western Ghats region (Karanth 2007; Madhusudan and Karanth 2002) and the preference for hunting with guns and snares that can potentially off-take higher levels of biomass, especially for the preferred medium to large-bodied animals, suggests that law enforcement patrolling is still a necessary management strategy for PTR.

In this study, hunting patterns between the sexes were found to markedly differ. Women were mostly involved in collecting bird eggs for household consumption. This was an activity that was carried out opportunistically while collecting fuel-wood and other forest products. Women normally do not participate in hunting mammals as it is riskier, e.g. it involves walking through forests at night and the stigma of going to trial if caught is considered to be significantly worse for women. In contrast, men predominantly hunted medium to large-bodied wildlife, which was used typically for household consumption or for sale at local markets. Hunting was not part of a community ritual, as it is in some other Asian ethnic groups (Aiyadurai *et al.* 2010; Datta 2002; Hilaluddin and Ghose 2005). Thus, providing communities with inexpensive, culturally appropriate and alternative sources of protein (e.g., poultry) is predicted to yield important reductions in the consumption of protected species. Furthermore, there is a changing economic situation in southern India with domestic meat becoming widely available and at lower prices than wild caught animals (Hilaluddin and Ghose 2005). Many of this study's respondents lived in places with good market access, so increasing awareness and strengthening market linkages in the rural communities should discourage wild meat use as a protein source.

Education was found to be an important determinant of hunting. Respondents with primary school level education or none were found to be more likely to hunt, probably because higher education enabled better paid and non-forest dependent jobs to be secured, as found in Northeast India (Hilaluddin and Ghose 2005). Though education levels in Kerala are among the highest in India, these benefits have not yet fully reached those living near PTR. Thus, it is anticipated that rural education programmes would be an effective way of delivering simultaneous conservation and livelihood benefits.

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INFLUENCE OF TROPHY HARVEST ON THE POPULATION AGE STRUCTURE OF ARGALI *OVIS AMMON* IN MONGOLIA

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To assess the influence of trophy hunting on Mongolian Argali *Ovis ammon*, we compared the ages of trophy rams (n=64) taken through Mongolia's legal hunting programme with those of mature rams that died of natural causes (n=116). A two-sample Kolomogorov-Smirnov test indicated that the distributions of the two groups were different (P=0.001). A two-sample t-test indicated the distributional differences were due, at least in part, to differences in the mean ages between the natural deaths and hunter harvested samples (P=0.001); the distributions were not centered at the same value or the means in the two populations differ. Application of the Central Limit Theorem affirms that the distribution of the sample mean ages for natural death and hunter harvested populations will be approximately normal, making the t-test applicable. The mean age for the natural death sample was 8.7 years (range: 7.0–13.0) compared to 9.4 (range: 7.0–13) for the hunter harvested sample. At the 95% confidence level, the true difference in ages between the trophy kills and natural deaths is between 3 months and 1 year. Since on an average, rams killed by hunters are older than the average age of natural death for mature rams, the legal hunting programme is having little effect on ram age structure. Thirteen years may represent the upper limit of lifespan for wild Mongolian Argali, which is slightly shorter than the life span of North American wild sheep, namely Thinhorn Sheep *Ovis dalli* and Bighorn Sheep *Ovis canadensis*.

Key words: Argali, age of mortality, natural mortality, trophy harvest age, trophy harvest effect

INTRODUCTION

Trophy hunting of large wild ungulates is controversial and a matter of concern to wildlife conservation practitioners (Coltman *et al.* 2003; Festa-Bianchet and Lee 2009; Frisina and Frisina 2004; Harris *et al.* 2002). Trophy hunting usually involves hunters seeking the largest males of a targeted taxon in a specific geographic area (Frisina *et al.* 2000). Revenues from trophy hunting fees can be a potential source of much needed funds for conserving wild species (Frisina and Tareen 2009; Harris *et al.* 2002; Schaller 1998; Valdez *et al.* 1995). Among the concerns regarding the harvesting of trophies by hunters are potential disruption of population social structure, social order, and maintenance of genetic diversity (Coltman *et al.* 2003; Festa-Bianchet 2003; Harris *et al.* 2002; Milner *et al.* 2006). To address this concern for Mongolian wild sheep populations, we compared the ages at which hunters harvest trophy rams with the ages at which mature rams were found dead in the field of natural causes. This approach may provide insights as to the degree that natural age structure may be altered, and thus, potentially impacting the natural dynamics of wild sheep populations in Mongolia.

Argali (*Ovis ammon*) are wild sheep that occur throughout central Asia, including Mongolia's steppe, undulating desert, and rugged mountainous landscapes (Geist 1991; Mitchell and Frisina 2007; Valdez 1982). Although their ranges are not well-defined and some overlap may occur, Shackleton and Lovari (1997) recognise two subspecies of argali as occurring in Mongolia: the Altai Argali (*O. a. ammon*) of western Mongolia and the Gobi Argali (*O. a. darwini*) of the Gobi Desert in southern Mongolia. Both are listed as rare by the Mongolian Government (MNEM 1997) and are included in the United States Fish and Wildlife Service list of endangered and threatened wildlife and plants (USFWS 2012). In addition, they are listed as vulnerable and endangered by the IUCN (2012) and in Appendix II of CITES (CITES 2012).

Mongolia is a central Asian landlocked country, encompassing about 1,656,000 sq. km of which approximately 25% is potential Argali habitat (ASM 1990). Limited international sport hunting of argali has been permitted since 1968. The current Mongolian hunting law was established in 1995 and is administered by the Mongolian Ministry for Nature and the Environment. The hunting law regulates the commercial use of wildlife. Although trophy hunting is controversial, hunting fees are an important source of foreign currency in a badly depressed economy (Asia Foundation 2009; MNEM 1995; Wingard and Purevdolgor 2001). Improved management of wildlife is one of Mongolia's best opportunities for diversifying an agriculture-based economy that will likely continue to depend on rangeland resource production (Valdez *et al.* 1995).

Argali populations are believed to have declined in Mongolia and throughout central Asia during the last century (Harper 1945; Heptner *et al.* 1989; Mallon 1985; Mallon *et al.* 1997; Reading *et al.* 1997). Specific and comparable country-wide population status and trend information for this species, a fundamental requirement for conservation (Wegge 1997), is limited. Population estimates for Mongolia reported by Frisina *et al.* (2007) and Frisina *et al.* (2010) indicate that from 2002 through 2009 Argali populations were stable to slightly increasing.

Here, we compare the ages of hunter harvested trophy rams with ages of mature rams found dead in the field of natural causes as a means to monitor the influence of trophy hunting on argali male age structure.

MATERIAL AND METHODS

Our study area included the entire Mongolian Argali range as described by Frisina *et al.* (2007). Mongolia's argali range is diverse, ranging from alpine communities in the Altai Mountains in the west, to steppe and desert communities in central and eastern areas. Plant communities are diverse and typical of the central Asian plateau (Hilbig 1995; Gunin *et al.* 1999). Several of our survey sites were previously described in detail (Frisina and Boldbaatar 1998; Frisina and Gombosuren 1999, 2000; Frisina *et al.* 2004, 2007, 2010).

Mongolia's climate is characterised by long, cold winters and short, humid summers. January is the coldest month with temperatures of -40°C or colder in contrast to >38 °C during summer. Rainfall is highly variable, averaging 460 mm in the mountains and 100 mm in the Gobi Desert. Severe winters and summer drought are not uncommon, and at times can lead to significant natural mortality of argali on portions of the range (Frisina *et al.* 2007).

From 1997 through 2002, mature argali rams five years or older found dead in the field of natural causes were aged using the horn growth segment ageing technique (Geist 1966). Wolves (*Canis lupus*) are a principle predator on argali (Schaller 1998). Among the other more common forms of natural mortality for mature males are predation by Snow Leopard (*Uncia uncia*), and stress imposed by a very severe environment. Animals found dead in the field were examined for indications of human caused mortality (i.e., head missing from mature males, bullet wounds, etc.). If no sign of human caused mortality was apparent the animal was included in the natural mortality sample. A number of trophies taken by hunters participating in Mongolia's legal hunting programme were likewise aged.

RESULTS

A sample of 64 argali rams of age 5 and older found dead in the field of natural causes was compared to a sample of 116 argali trophies harvested by hunters through Mongolia's legal hunting programme. Relative frequency of occurrence in relation to age for both samples is graphically displayed in Fig. 1. A two sample Kolomogorov-Smirnov Test (KS) indicated the distributions were different (P = 0.001). A two-sample t-test was used to determine if the distributional differences were at least in part due to differences in the mean ages between the natural death and hunter harvested samples. The two-sided two-sample t-test resulted in a P-value of 0.001, indicating the distributions were not centred at the same value, or the mean ages in the two populations differ. Application of the Central Limit Theorem affirms that the distribution of the sample mean ages for natural death and hunter harvested populations will be approximately normal, which allows for the valid use of the two sample t-test (Ramsey and Schafer 2002). The mean age for the natural death sample of 64 was 8.7 years (range: 7.0–13.0) compared to 9.4 years (range: 7.0–13.0) for the hunter harvested sample of 116. Applying a 95% confidence interval, we determined the true difference in ages between the trophy killed argali and those that died of natural causes is between 3 months and 1 year, with the trophy killed argali living longer.

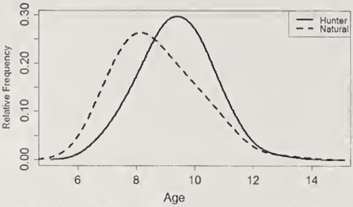

Fig. 1: Age distribution and frequency of occurrence for natural mortality and hunter harvested mature rams of Argali in Mongolia

Table 1: Mongolian Argali harvest quotas 1992 through 2011

Year(s)	*Harvest Quota
1992-1994	15
1995-1996	20
1997	30
1998	35
1999	45
2000	40
2001	45
2002-2006	80
2007-2009	60
2010-2011	50

*Baasanhu Jantzen and Mongolian Ministry for Nature and the Environment (pers. comm.).

These data indicate that the natural life expectancy for rams surviving their first five years is, on the average, only an additional 3.7 years. The oldest argali in our sample included a hunter trophy aged 13 years, and a natural death of the same age.

DISCUSSION

Hunter Harvest

The average age of rams killed by hunters (9.4) is older than the average age of natural death (8.7) and indicates that Mongolia's legal trophy hunting programme is having little effect on the mature ram age structure. Ideally, mortality resulting from trophy hunting should remove animals destined to die shortly of natural causes (Wegge 1997); this appears to be the case for most of the Mongolian trophy harvest. Our results are similar to Schaller (1998) who described argali as animals with a relatively short lifespan, seldom reaching 10 years. Natural environmental factors and interacting population parameters are apparently exerting more influence on its life expectancy than the trophy hunting programme, partially a result of Mongolia limiting harvest quota system. The selective effects of trophy hunting can be expected to increase with intensity of hunting pressure (Festa-Bianchet *et al.* 2006) and, conversely, have limited effect at low harvest levels. Quotas varied by year, from 15 to 80 from 1992 through 2011 (Table 1). Mongolia's harvest quota is conservative relative to total argali numbers. Using different methods Frisina *et al.* (2010) and Harris *et al.* (2010) developed population estimates of 26,155 and 17,903 argali respectively for fall 2009. Using these estimates, Mongolia's current harvest quota of 50 potentially allows for harvest of 0.2 to 0.3 % of the total population in trophy rams. Following a 2002 census in which 20,226 argali were estimated, Frisina *et al.* (2007) determined that with a conservation plan in place a sustainable quota of 202–404 individuals could potentially be harvested. Harris (1993), following a review of the literature for large ungulates with polygamous breeding strategies, determined that with a conservation plan in place harvest quotas representing 1 to 2% of the total population may be sustainable. Swank (1958) recommended limiting trophy harvest to not more than 12% of the males in the population and Wegge (1997) indicated that harvesting males within 10 to 20% of the replacement level for the trophy-sized segment is safe and not expected to have any negative effects. Mongolia's harvest quota is well within these limits. The apparent lack of hunting impact upon age structure of mature males supports the conclusion that present hunting quotas are appropriate. If harvest levels increased significantly, the influence of hunting on age structure may increase.

Life Span

Thirteen years may represent the upper limit of lifespan for wild argali in Mongolia. Schaller (1998) reported a maximum age between 10 and 11 years for argali of the Tibetan steppe. Maximum ages reported for North American Thinhorn Sheep *Ovis dalli* ranged between 13 and 15 years (Deavey 1947; Loehr *et al.* 2007; Simmons *et al.* 1984). Similarly, Hansen (1961) reported a maximum age of 15 years for Bighorn Sheep *Ovis canadensis*. It appears that argali may have a slightly shorter maximum lifespan than these two species of North American wild sheep.

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ESTIMATING FOOD INTAKE FROM SCATS IN THE OMNIVOROUS INDIAN FOX *VULPES BENGALENSIS*

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The Indian Fox *Vulpes bengalensis* is an omnivorous canid and has been reported to feed on a wide range of food items. However, the correction factor for assessing food intake from prey occurrence in scats has not been evaluated. We determined the relationship between food intake and the number of field-collectible scats produced in three captive foxes. A total of 14 feeding trails were conducted with food items ranging from <2 gm (insects) to ~2,000 gm (rabbits and some body parts of goats). Foxes ate on an average of $178.24_{\text{Mean}}\pm29.55_{\text{SE}}$ gm of food and produced $10.23_{\text{Mean}}\pm1.39_{\text{SE}}$ collectible scats/individual/day during feeding trial experiments. The percentage of non-collectible scats ranged from 2.98% to 12.22%, and averaged 7.14% (0.77 SE) of total scats produced. Digestibility index was lowest for smaller prey items. The prey biomass eaten per collectible scat (Y) increased as the live body weight of prey (X) increased (Y= 0.013 (SE 0.002) x prey weight (gm) + 6.76 (SE 2.25), $R^2 = 0.78$, $F_{(1, 11)} = 39.43$, $P = 0.0001$), which can be used to compute biomass consumption from scat data.

Key words: biomass consumption, digestibility, feeding trails, linear regression

INTRODUCTION

Accurate knowledge of food consumed by carnivores is essential to understand their ecology and help formulate conservation strategies. Studies on the feeding ecology of carnivores are widely carried out by scat analysis. Scat analysis is non-invasive, cost-effective, and determines the range of food items utilised by carnivores (Corbett 1989; Reynolds and Aebischer 1991). Various methods have been widely used to interpret scat data across carnivore taxa. The most commonly used method for scat data interpretation is frequency of occurrence, which is expressed as the proportion of scats containing a particular prey item (Klare *et al.* 2011; Reynolds and Aebischer 1991). This estimate is biased towards prey with a smaller body size because smaller animals have a higher surface to volume ratio than larger animals (Floyd *et al.* 1978; Mech 1970) and therefore have more indigestible material per unit mass. Therefore, a correction factor developed from feeding trial experiments needs to be applied to estimate the actual biomass consumed from frequency of occurrence in scats (Ackerman *et al.* 1984; Floyd *et al.* 1978; Jethva and Jhala 2004; Lockie 1959; Mukherjee and Goyal 2004; Ruhe *et al.* 2008; Wachter *et al.* 2012). Such a relationship is lacking for the Indian Fox. The conversion factor for calculating biomass consumption has been developed for Red Fox *Vulpes vulpes* (Lockie 1959; Ruhe *et al.* 2008). However, this conversion may not be applicable for the Indian Fox *Vulpes bengalensis* due to its smaller body size (<3 kg) and diet which mainly consists of smaller food items such as arthropods, rodents, reptiles, and fruits (Home and Jhala 2009; Manakadan and Rahmani 2001; Maurya 2012; Vanak and Gompper 2009) in semi-arid habitats of the Indian subcontinent. Hence, we carried out an investigation to find out the relationship between prey mass eaten and the number of scats produced through feeding trials on captive Indian Fox.

MATERIAL AND METHODS

Feeding trial experiments were carried out at the field base camp of Wildlife Institute of India in Abdasa taluka (23° 17' N; 68° 56' E), the south-western province of Kachchh district of north-western Gujarat, India. Three captive subadult foxes (a male and two females) were used for feeding trials following the procedure suggested by Floyd *et al.* (1978) and Jethva and Jhala (2004). Before commencing each trial, foxes were fasted for 48–72 hours, to clear their digestive system and reduce the effect of the previous diet. A total of 14 feeding trials of seven different food items were conducted (Table 1). A single food type was given in each trial. Water was provided *ad libitum.* Rabbit *Oryctolagus* spp., rat *Rattus norvegicus*, Indian Desert Jird *Meriones hurrianae*, chicken *Gallus domesticus*, reptiles, insects, and fruits were provided whole, whereas only parts of goat *Capra hircus* were provided (1–2 kg). Food items were kept in the enclosure until the foxes stopped feeding on them. No further food was provided until scat production ceased (110 hrs average time). Most of the edible portion of the prey items was consumed within 2 days for large prey, such as rabbit and goat parts. However, rodent, insects, reptiles, and fruits were consumed on the same day of the feeding trial. Uneaten prey items were removed and weighed (0.1 gm accuracy) to determine the amount of food consumed.

Since weight of uneaten parts needs to be subtracted from food offered to compute the consumed amount, it was necessary to compute moisture loss from the food parts that were not consumed. Moisture loss from provided food items was assessed for 12–84 hrs. Known weight of food items were exposed to the environment and weighed every 12 hrs. Moisture loss rate per hour was calculated for each food item by computing percent of weight loss due to evaporation. Thus, the consumed food weight was calculated by accounting for the amount of moisture lost from the non-consumed part of food weight.

Scats were classified into two categories according to their structure: collectible (firm faeces) and non-collectible (watery and loose faeces) (Floyd *et al.* 1978; Jethva and Jhala 2004). Scats were collected three times in a day in order to minimise trampling. All the scats produced during the feeding trials were collected and sun dried for 4–5 days (noon temperature >40° C and 5–10% humidity), and weighed to nearest 0.1 gm. For each food item, we divided the amount (gm) of food eaten by the number of collectible scats to estimate the amount eaten that produced a (collectible) scat. Simple linear regression analysis (Ackerman *et al.* 1984; Floyd *et al.* 1978; Jethva and Jhala 2004) was used to establish a relationship between biomass consumed per collectible scat (y) and food item weight (x). Outliers were excluded from the final regression using criteria more than two standard errors in residual diagnostic process (Zar 1984). Recently, Wachter *et al.* (2012) developed a polynomial regression model for Cheetah *Acinonyx jubatus*, but we did not adopt this approach as the offered food items were within the range a fox would consume in the wild, and therefore, the biomass consumed per collectible scat would not reach an asymptote for the range of prey items fed to the foxes. Digestibility index (D) was calculated using fresh weight consumed and fresh weight of scats (Robbins 1983; Ruhe *et al.* 2008).

$$\text{Digestability Index} = \frac{\text{Fresh weight of prey consumed} - \text{Fresh weight of all collectible scats}}{\text{Fresh weight of prey consumed}}$$

RESULTS

Foxes completely consumed smaller food items like rodents, beetles, and reptiles on the same day, while larger food items weighing (>2 kg) like rabbit, chicken, goat's leg and fruits were fed upon for 2 days. Average consumption by foxes was $87_{\text{Mean}}\pm3.7_{\text{SE}}\%$ (min=55%, max=100%) of the

Table 1: Details of feeding trials on three Indian Fox

S. No.	Food Items	Food Weight (gm)		Food used (%)	Scats		Digestibility Index (%)	Amount (gm) eaten per collectible scat
		Offered	Consumed		Collectible	Non-Collectible		
1	Beetles	85	85.0	100	20	0	32.94	4.25
2	Beetles	225	225.0	100	36	7	53.56	6.25
3	Rabbit	1630	1511.0	93	53	29	89.58	28.51
4	Rabbit	1530	1407.6	92	51	27	91.90	27.60
5	Rodents	205	205.0	100	13	9	67.80	15.77
6	Rodents	1050	920.0	88	67	3	80.16	13.73
7	Chicken	1200	759.5	63	25	31	93.81	30.38
8	Chicken	1520	1200.2	79	45	7	88.67	26.67
9	Reptiles	341	341.0	100	30	2	83.87	11.37
10	Goat	1850	1023.7	55	34	7	91.01	30.11
11	Goat	1050	853.1	81	22	14	91.50	38.78
12	*Ziziphus* fruit	600	497.9	83	23	36	70.08	21.65
13	*Phoenix* fruit	500	465.3	93	36	3	74.96	12.93
14	*Phoenix* fruit	500	436.5	87	44	1	74.34	9.92

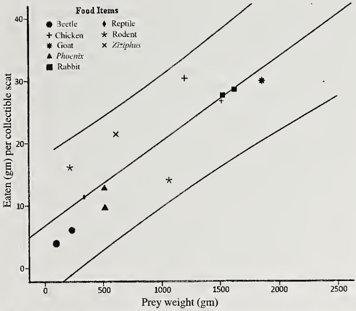

Fig. 1: Linear regression (with 95% confidence interval) between biomass consumed per collectible scat (Y) and average weight of food items (X) (Y= 0.013 (SE 0.002) × prey weight (gm) + 6.76 (SE 2.25), $R^2 = 0.78$, $F_{(1,11)} = 39.43$, P = 0.0001)

offered food weight (Table 1). Foxes consumed most of the soft body portion of larger food items. Only bones and hide were left unconsumed. The average percentage weight loss due to evaporation within 48 hours was highest for chicken (4.9%) and goat's leg (4.5%), than fruits (2.1%) and rabbit (1.1%). The percentage of non-collectible scats ranged from 2.98% to 12.22%, and averaged 7.14% (0.77 SE) of total scats produced.

Food consumption by foxes was correlated to the digestibility of food items. Digestibility of beetles was lowest, followed by chicken, rabbit, fruits, and rodents (Table 1). Digestibility index averaged 77.4% (SE=4.6) and was positively correlated to the weight of food item ($r_s = 0.82$, p=0.0001), while the percentage of food items consumed was negatively correlated to digestibility ($r_s = -0.65$, p=0.006). Foxes ate on average $178.24_{\text{Mean}} \pm 29.55_{\text{SE}}$ gm of food and produced $10.23_{\text{Mean}} \pm 1.39_{\text{SE}}$ collectible scats/individual/day during the feeding trial experiments. There was a strong relationship between prey weight and the number of scats produced during feeding trials. One feeding trial of goat was detected as an outlier (std. residual=2.48) among the 14 sample data sets and excluded from further analysis. The prey biomass eaten per collectible scat (Y) increased as the live body weight of offered prey (X) increased (Fig. 1). A regression on these variables generated the following equation: Y= 0.013 (SE 0.002) × prey weight (gm) + 6.76 (SE 2.25), $R^2 = 0.78$, $F_{(1,11)} = 39.43$, P = 0.0001), which can be used to assess the quantity of biomass consumption from different food items recorded in fox scats. Individual correction factors for broad food items for biomass (gm) consumed per collectible scat were 5.3 (SE 1) for arthropods, 25.75 (SE 3.9) for mammals, 28.5 (SE 1.9) for birds, 11.4 for reptiles, and 14.8 (SE 3.5) for fruits.

DISCUSSION

The Indian Fox is a small canid (<3 kg body weight) and an opportunistic solitary forager that feeds on food items smaller than its body mass, mainly consisting of arthropods, rodents, hare, reptiles, birds, fruits, and occasionally scavenging on livestock carcasses (Home and Jhala 2009; Maurya 2012; Vanak and Gompper 2009). Most of the food items offered during our feeding trial experiments conducted were consumed on the same day as also observed in free ranging foxes through radio-telemetry (Maurya 2012). Rodents, arthropods, and reptiles were consumed whole including the fur, bones, and scales, while mostly soft and edible parts were eaten from livestock carcasses. Although, livestock carcasses such as goats, sheep and cattle are not important food items in their diet, constituting less than 1% (Home and Jhala 2009; Maurya 2012), we included them in the experiment to cover the range of species utilised by them. The Indian Fox diet of livestock are leftover parts of kills made by other large predators, such as wolves and hyenas, and thus, they try to consume the most digestible part quickly due to risk of encounters with the larger carnivores, while feeding on the carcasses.

The digestibility of larger food items was higher than smaller prey as reported from other studies (Floyd *et al.* 1978; Jethva and Jhala 2004; Ruhe *et al.* 2008) because smaller prey species have a greater proportion of indigestible materials than larger prey species, and therefore consumption of small prey species resulted in a higher number of collectible scats. The mean digestibility of arthropods and mammalian prey items in Indian Fox was similar to that reported for Red Fox *Vulpes vulpes* (Ruhe *et al.* 2008) and Badger *Meles mels* (Rosalino *et al.* 2003). Litvaitis and Mautz (1976) fed Snowshoe Hare *Lepus anzericanus* and White-tailed Deer *Odocoileus virginianus* to captive Red Fox and estimated digestible dry matter at 82% for hare and at 97% for deer. Similarly, Johnson and Hansen (1979) reported that for coyotes *Canis latrans*, the digestibility of mammals was 80% and that of birds 60%. Thus, the digestibility index values obtained in this study are comparable to these studies and also in agreement with the hypotheses that, in terms of weight, small prey were over represented in frequencies of remains in fox scats (Floyd *et al.* 1978; Jethva and Jhala 2004; Ruhe *et al.* 2008; Weaver 1993). We observed that when fruits especially of *Ziziphus* were fed to foxes, a large number of non-collectible scats (Table 1) were produced. These non-collectible scats were usually grayish black and fluid, reflecting low digestibility, and would generally be missed during field studies (Ackerman *et al.* 1984; Floyd *et al.* 1978).

The average body weight of an adult Indian Fox is $2.24_{Mean} \pm 0.13_{SE}$ kg (Johnsingh and Jhala 2004; Maurya 2012). From our data, the daily food intake for foxes was computed to be 0.112 kg fresh weight per kg body mass or about 0.25 kg $fox^{-1} day^{-1}$ and the daily food intake per metabolic body weight (McNab 1980) was 0.14 kg $kg^{-0.75}$ The consumption rate of food in Indian Fox was found to be lower than that recorded for the Red Fox (0.22 kg/MBW Stahl 1990; 0.24 kg/MBW Webbon *et al.* 2004). Sargeant (1978) reported food consumption of adult Red Fox 2.48 kg/adult/week (0.69 kg $kg^{-0.75}$ prior to whelping, and 3.62 kg/adult/week (1.01 kg $kg^{-0.75}$) after whelping. In arid habits foxes have smaller body mass and lower basal metabolic rate (BMR), e.g., Fennec Fox *Vulpes zerda* (281.1 kJ/d, Maloiy *et al.* 1982), Kit Fox *Vulpes macrotis* (485.5 kJ/d, Golightly and Ohmart 1983), Blanford's Fox *Vulpes cana* (304.5 kJ/d, Williams *et al.* 2004) and Rüppell's Fox *Vulpes ruepellii* (385.4 kJ/d, Williams *et al.* 2002) in comparison to foxes inhabiting mesic environments, e.g., Red Fox (1,195.5 kJ/d Williams *et al.* 2004). We find support for the hypothesis that lower consumption of food by the Indian Fox could be an adaptation to arid environment by lowering BMR so as to have a selective advantage in times of low resources abundance in arid environments (McNab 1980; Williams *et al.* 2004). In the wild, arthropods constitute a major portion of the Indian Fox diet (Home and Jhala 2009; Manakadan and Rahmani 2001; Maurya 2012; Vanak and Gompper 2009). Indian foxes are not known to hoard food; thus their survival and reproductive output seems to depend on regular foraging on energy rich food sources.

Ruhe *et al.* (2008) estimated the conversion factor for each prey species by dividing the prey mass offered by the dry mass of scat remains after washing through a 2 mm sieve. Lockie (1959) derived the correction factor by dividing the prey mass offered to Red Fox by the amount of undigested matter. Both these studies did not incorporate the actual amount of food consumed after correcting for moisture loss. In our study, we estimated the amount (gm) eaten per collectible scat and regressed this against prey weights offered, which provides estimate of biomass eaten per collectible scat from different size food items. We suggest that this regression relationship would be more robust for evaluating food habits than individual conversion factors especially for mammalian, avian, and reptilian diet. However, the broad taxa based conversion factors developed by us for amount of biomass consumed to produce one collectible scat may be more appropriate for fruit and arthropod remains in scat (Atkinson *et al.* 2002; Loveridge and Macdonald 2003). The regression equation developed in this study, shows a significant relationship between weight of food offered and number of scats produced, as has been reported in wolf and cougar (Ackerman *et al.* 1984; Floyd *et al.* 1978; Jethva and Jhala 2004). Wachter *et al.* (2012) developed an exponential regression model to compute prey biomass consumed per collectible scat by cheetah, wherein after a certain large mass of prey, scat production reaches an asymptote. Since we offered food amounts that are likely to be naturally encountered in free ranging condition, we did not see an asymptote in the relation between prey weight and number of field collectible scats. Thus, our regression model is in the lower linear range of the exponential function. If however, foxes were offered full prey carcasses of goat, sheep, and cattle of >10 kg, we would expect an exponential model to fit better since the number of scats produced cannot increase indefinitely and reach a plateau at higher prey body masses. In the field, Indian Fox scats contains more than one prey item. To apply this equation to estimate biomass consumption, one should use the number of whole scats equivalents for a particular food item by adding the proportion of each food item constituting the scats rather than the percentage of occurrence (Maurya 2012). The regression relationship developed herein is likely to provide a more robust understanding on the diet of Indian Fox and related canids that feed on a mixed diet of fruit, arthropods, rodents, reptiles, and lagomorphs.

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THE 'STATE OF AFFAIRS' OF THE ASIAN ELEPHANT *ELEPHAS MAXIMUS* IN THE HOSUR AND DHARMAPURI FOREST DIVISIONS OF TAMIL NADU, INDIA

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We discuss the state of affairs of the Asian Elephant in the Hosur and Dharmapuri forest divisions based on studies undertaken from November 2006 to June 2007, and also through a comparison of the situation prevailing there as reported from an earlier study in the late 1980s to early 1990s. The situation of elephants in the two divisions is alarming due to the decline in elephant population from dispersals and unnatural deaths, skewed sex-ratio in favour of females, severe habitat loss and degradation, proliferation of the exotic weed *Lantana camara*, problems of human-elephant conflict, and from other human-related pressures on the forests.

Key words: *Elephas maximus*, Eastern Ghats, Hosur reserve forest, Dharmapuri reserve forest, population, conservation issues, human-elephant conflict, *Lantana camara*

INTRODUCTION

The elephants of the Hosur and Dharmapuri (henceforth, Hosur-Dharmapuri) reserve forests came into the limelight during the mid-1980s with the first reported instance of elephant dispersals in India (Ramesh Kumar and Desai 1992; Manakadan *et al.* 2010), a phenomenon subsequently reported in a few other elephant ranges, primarily due to habitat loss, fragmentation and degradation (see Sarma and Easa 2006; Singh 2002). The elephants that dispersed from Hosur-Dharmapuri forests colonised two sites in southern Andhra Pradesh, a state that did not have a history of elephant presence for 200 years (Manakadan *et al.* 2010; Syam Prasad and Reddy 2002).

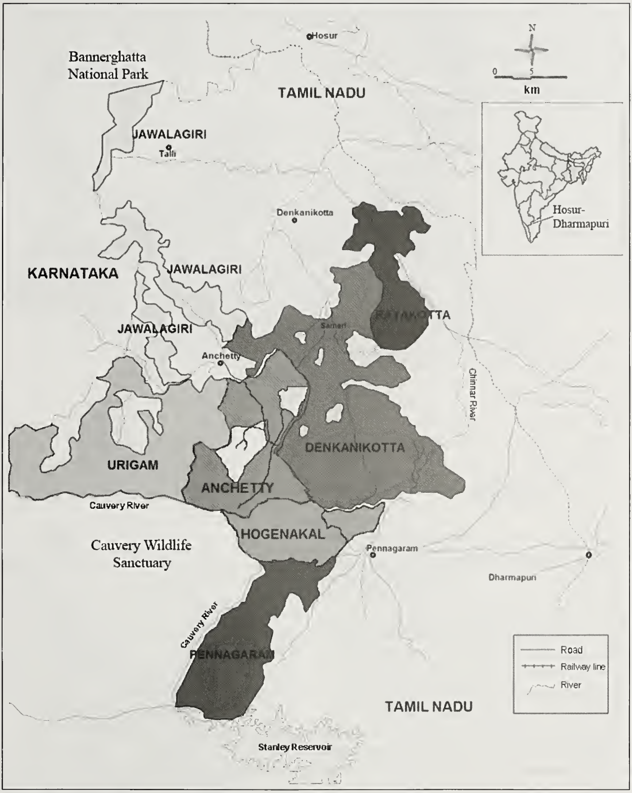
Investigations into the issue of elephant dispersal and colonisation are important to help wildlife managers understand the reasons for dispersals and more efficiently manage problems associated both with dispersal and colonisation. Hence, after undertaking a study in one of the colonised sites, Koundinya Wildife Sanctuary (Daniel *et al.* 2006), we undertook a study in the Hosur-Dharmapuri forests from Nov. 2006 to Jun. 2007 (Daniel *et al.* 2008). In this paper, we discuss the state of affairs of the Asian Elephant in the Hosur-Dharmapuri forest divisions based on the studies undertaken, and also in comparison with the situation reported prevailing during an earlier study (Ramesh Kumar 1994).

STUDY AREA

The contiguous reserve forests of Hosur and Dharmapuri forest divisions (11°48' –12°44' N; 77°30' – 78°47' E) fall under the districts of Krishnagiri and Dharmapuri of Tamil Nadu (Fig. 1) and are part of the Eastern Ghats mountain range of peninsular India. The Hosur Forest Division (1,280 sq. km) has seven ranges: Jawalagiri, Denkanikotta, Anchetty, Urigam, Rayakotta, Hosur, and Krishnagiri. The Dharmapuri Forest Division (876 sq. km) consists of the Hogenakal and Pennagaram ranges. There is a long-pending proposal to demarcate and declare a portion of the Hosur-Dharmapuri area as a sanctuary. Forest tracts that adjoin Hosur-Dharmapuri are Bannerghata National Park in the north and Cauvery Wildlife Sanctuary in the west.

The altitude ranges from 400 to 1,000 m above msl. The two main drainages are Doddahalli in the west and Chinnar in the east, both draining into the River Cauvery which runs along its southwestern boundary. The rainfall is primarily from the southwest monsoon varing from 700 to 950 mm/annum. During winter (December–February), the temperature often falls below 10 °C. The maximum temperature is generally under 25 °C, and seldom crosses 35 °C (Ramesh Kumar 1994; Subiah 1982).

The forest is predominantly the dry mixed deciduous type. There are a few small patches of dry evergreen species in the Denkanikotta range. Dry deciduous and scrub forest occur around the boundary of forests and along roads due to high biotic pressures. Riverine forests occur along the banks of Cauvery, Doddahalli, Chinnar and semi-perennial streams. This forest tract was well known for sandalwood (*Santalum album*), and protection to this and other timber species began during Tipu Sultan's rule. Large areas were brought under


Hosur
Bannerghatta National Park
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Hosur-Dharmapuri
Denkanikotta
KARNATAKA
JAWALAGIRI
RAYAKOTTA
Sanari
JAWALAGIRI
Anchetty
Chinnar River
DENKANIKOTTA
URIGAM
ANCHETTY
Cauvery River
HOGENAKAL
Cauvery Wildlife Sanctuary
Pennagaram
Dharmapuri
Cauvery River
PENNAGARAM
Road
Railway line
River
TAMIL NADU
Stanley Reservoir

Fig.1: Map showing the seven elephant inhabited ranges of the Hosur-Dharmapuri forest divisions (excluding Hosur and Krishnagiri ranges) with adjoining areas

British rule through treaties with Tipu in 1792 and 1799. After this, the forests underwent relentless exploitation, especially for sandalwood and timber, till they were notified as reserve forests in 1886. Nevertheless, the forests, due to their status as reserve forests where locals have some rights to the land, continued to experience significant destruction through permitted or illegal grazing and exploitation of bamboo, fuel-wood, timber and minor forest produce. The exotic shrub *Lantana camara* has spread extensively throughout the forest (Ramesh Kumar 1994; Subiah 1982).

There are 27 enclave and around 95 fringe villages with cultivated areas (largely in the plains) in the Hosur-

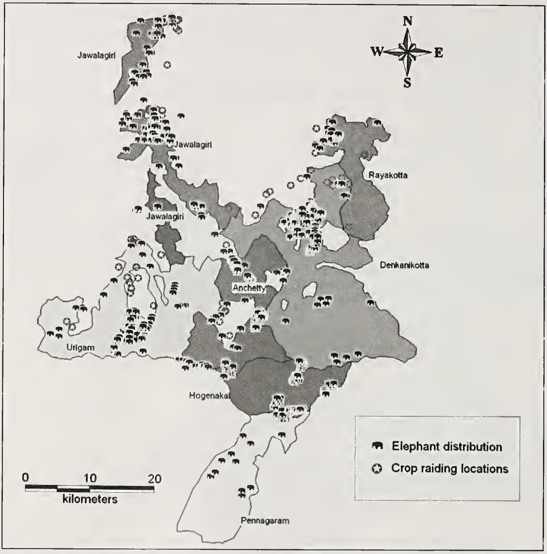

Fig. 2: Distribution of elephants in the seven elephant inhabited ranges of Hosur-Dharmapuri forests from Nov. 2006 to Jun. 2007 – based on sightings, indirect signs, and crop-raiding records

Dharmapuri division with a total human population of around 80,000. The major sources of revenue/employment for the locals are from agriculture, livestock rearing, wood-cutting, sale of non-timber forest produce, sericulture, fruit juice and dry food processing, granite extraction, and brick manufacturing. A recent development is the construction of farm houses and resorts. Ragi (*Eleusine coracana*), other minor millets, and pulses are the major crops in the area, besides paddy, banana, sugarcane, cotton, groundnut, and vegetables. Cattle and sheep of the enclosure and fringe villages are permitted to graze in the forest. The entry of goats is banned but it is not uncommon to see goats accompanying other livestock in the forests. The density of livestock varies between 77 animals/sq. km to 272 animals/sq. km in the different areas, with an average density of 165 animals/sq. km (Subiah 1982).

METHODOLOGY

Two of the nine ranges of the Hosur Forest Division (namely, Hosur and Krishnagiri ranges) lie amidst human habitation areas and have patchy vegetative cover, and have not been frequented by elephants since the past few decades (Ramesh Kumar 1994). Because of this and following Ramesh Kumar (1994) study, our studies were confined to only seven ranges, namely, Jawalagiri, Denkanikotta, Anchetty, Urigam, Rayakotta, Hogenakal and Pennagaram.

The methodologies of the studies are as follows:

Elephant Population and Distribution: All the seven ranges were surveyed extensively with efforts to cover all areas thoroughly and equally, and all direct (sightings) and indirect evidence (dung, feeding signs and tracks) of elephant presence were recorded with GPS. Information of elephant presence was also solicited from herdsmen, woodcutters, and Forest Department field personnel.

Biotic Pressures: Quantification of biotic pressures (namely, woodcutting, grazing using dung abundance as an index, and weeds) was carried out using >5 km belt transects,

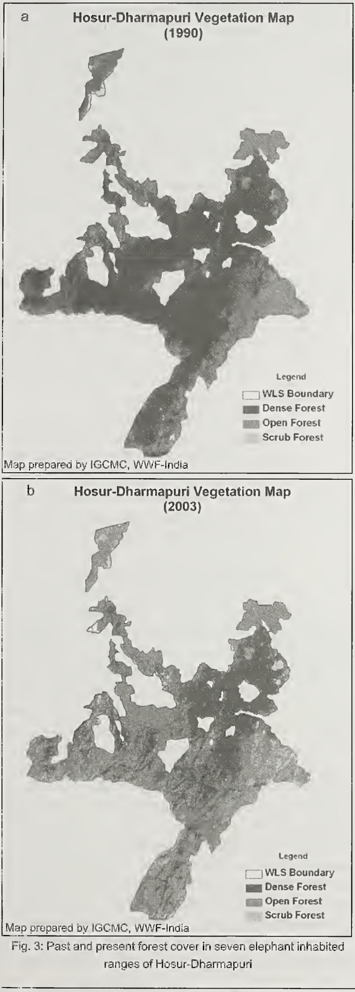
a
Hosur-Dharmapuri Vegetation Map (1990)
Legend
WLS Boundary
Dense Forest
Open Forest
Scrub Forest
Map prepared by IGCMC, WWF-India
b
Hosur-Dharmapuri Vegetation Map (2003)
Legend
WLS Boundary
Dense Forest
Open Forest
Scrub Forest
Map prepared by IGCMC, WWF-India

Fig. 3: Past and present forest cover in seven elephant inhabited ranges of Hosur-Dharmapuri

orienting from 13 village boundaries towards the forest interiors. Data was collected at 100 m intervals for a length of 100 m (width of 2 m on either side), recording the tree species (>10 cm girth), number of cut trees/stems, and the abundance of cattle dung. The presence of the weed *Lantana camara* was sampled at the end of each 100 m segment using a 5 sq. m quadrat.

Human-Elephant Conflict (HEC): Information on past HEC cases was obtained from Forest Department records and published data (Ramesh Kumar 1994). For current HEC data, besides relying on current crop compensation claims in Forest Department records, we carried out a HEC survey in 92 villages. The data recorded included the villages raided, crop species raided, property damaged, the extent and nature of the damage, and the age-sex and group size of the raiding elephants. The distances of the raided crop fields to nearby water sources were also recorded.

Changes in Forest Cover: Topographic maps and recent (2003) and old (1990) satellite imageries of the study area were procured and classified using GIS techniques for assessing changes in the forest cover over the years. The imageries used were: 1990 (Landsat, 30 m resolution; Feb. and Dec. 1990; 4 images), and 2003 (IRS, P4/L-3; 30 m resolution – after rescale from 24 m; Sep. and Dec. 2003; 4 images).

RESULTS

Population and Distribution of Elephants

A total of 5 bulls (2 adults and 3 subadults) and five herds in different areas were sighted from November 2006 to June 2007. The bulls consisted of an adult and a subadult tusker in Denkanikotta Range, a subadult tusker in Urigam Range, a subadult tusker in Anchetty Range and a *makhna* in Jawalagiri Range. Two bulls, a *makhna* and a subadult bull, died during the study, the *makhna* being the one sighted earlier. The five herd sightings consisted of a minimum of 6 animals in the Jawalagiri Range, 15 in Denkanikotta Range, 15 in Anchetty Range, 12 in Hogenakal Range and 8 in Pennagaram. A total of 195 dung and 340 feeding signs of elephants were recorded from November 2006 to June 2007 (Fig. 2), which revealed that elephants ranged in all the seven ranges.

Changes in Forest Cover

Comparison of the past (1990) and the recent (2003) imageries of the vegetation cover of Hosur-Dharmapuri forest division (Fig. 3) revealed that dense forest cover had decreased from 1,006.4 sq. km to 529.6 sq. km, open forest had increased from 359.8 to 634.4 sq. km, and scrub forest had increased from 27.1 to 205.7 sq. km. Overall, the images revealed that

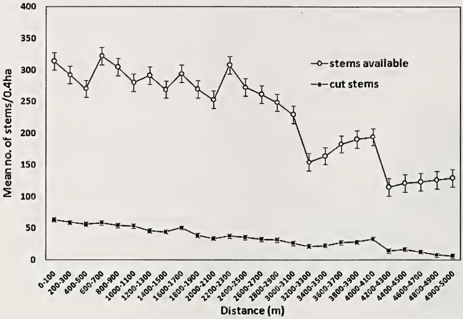

Fig. 4: Woodcutting pressures from 13 village boundaries towards interior forests in Hosur-Dharmapuri

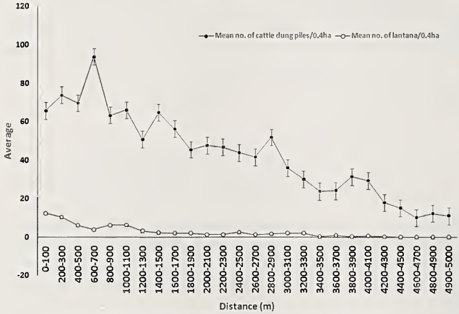

Fig. 5: Abundance of cattle dung piles and *Lantana camara* from 13 village boundaries towards interior forests in Hosur-Dharmapuri

the forests of Hosur-Dharmapuri have become significantly more open due to loss of tree cover.

Biotic Pressures

Woodcutting: The number of cut stems was recorded to gradually decrease with increase in distance from villages (Fig. 4), as woodcutting is more prevalent near village borders. However, the results also revealed that woodcutting extends throughout the forest mainly because the forest has enclave villages within its confines.

Grazing: The density of cattle dung showed a decline with increase in distance from villages till around 2.5 km (Fig. 5).Thereafter, there was a sharp increase due to the proximity to the next village. After this, there was again a decline as transects were not laid in the direction of adjoining villages but as far away as possible from them. The decline in dung density towards forests besides being related to higher grazing pressures near villages is also a result of reduced defecating rates. It is well known that cattle tend to defecate more in the morning as they move out into the forest and again in the evenings on their way back. This pattern is exploited in many areas by releasing cattle in the late mornings and then bringing them back by evening so that the deposited dung can be collected for manure. Overall, the results showed that grazing by livestock is rampant thoroughout the forest.

Lantana camara: The exotic weed *Lantana camara* was recorded throughout the forest; its abundance was more near villages due to higher biotic disturbances (Fig. 5). Its spread was found to depend on soil type, being scarce and with poor growth in crystalline soil areas.

Human-Elephant Conflict

Human Mortalities: Human mortalities from elephants were almost an annual feature with a total of 21 deaths reported from 2001 to 2008 (Fig. 6), averaging 2.8 human deaths/year. We recorded two human deaths in one day by a bull elephant during the study period, and two more deaths were subsequently reported within a year.

Elephants Mortalities: Seventy-four elephant deaths were reported from 1991 to 2008 (Fig. 7), averaging 4.5 elephant deaths/year. The majority of the deaths were reported as natural deaths, but in the absence of timely post-mortems or early detection of the carcasses, it is difficult to accurately know the actual cause of death, and many such cases get reported as due to natural causes. Passing off poached animals or animals killed during crop raiding as natural death also frees the Forest Department from problems that would arise if reported otherwise. Five mortalities were recorded during the study period: a subadult tusker shot in a crop field at Denkanikotta, a cow that died due to "delivery complications" in Anchetty Range, a subadult cow casualty reportedly from anthrax in the Anchetty Range, an adult *makhna* that fell into a well at the outskirts of Rayakotta Range, and a cow that died of "old age" in the Rayakotta Range.

Crop Raiding: Forest Department records had 1,685 crop damage claims from 2001 to 2008 (Fig. 8). The data showed a sharp increase in crop raids during 2006–07 and 2007–08, but according to locals and some Forest Department personnel, this was only because the new Divisional Forest Officer was keen that all affected villagers received compensation and took serious efforts in this direction. We recorded a total of 48 raids spread over 30 villages from November 2006 to March 2007. The majority (94%) of the raids was by family herds (Fig. 9).

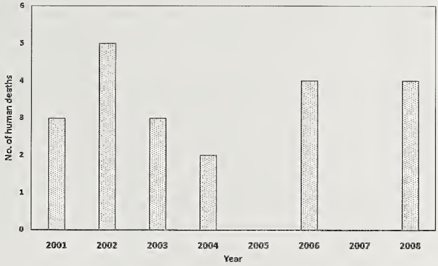

Fig. 6: Manslaughter in the Hosur-Dharmapuri area from 2001–2008

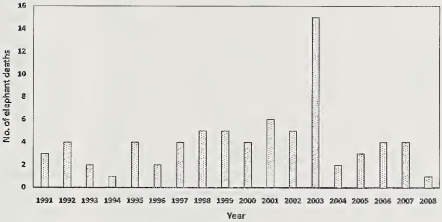

Fig. 7: Elephant mortalities in the Hosur-Dharmapuri area from 1991–2008

DISCUSSION

Decline in Elephant Population: Ramesh Kumar (1994), who carried out an intensive study from December 1988 to January 1993, estimated the resident elephant population of the Hosur-Dharmapuri forests at an "annual minimum" of around 17 bulls and 241 individuals of family units, totalling 258. The Synchronized Elephant Census (SEC) of 1998 reported around the same population, namely 277 animals (AERCC 1998). However, the 2002 SEC reported significantly higher numbers: 590 for Hosur and 243 for Dharmapuri (Anon. 2002). Considering the difficult terrain, large areas to be covered, trained manpower requirements for such an exercise, and the earlier tendency of the Forest Department staff to show higher growth population figures of wildlife in their areas, we feel the 2002 SEC figure is erroneous. The fact that these forests are contiguous with other forests permitting movement of elephants between sites also adds to the problem – inspite of the census being conducted simultaneously over elephant ranges.

Comparison of past and present figures revealed a decline in the elephant population over the years. Ramesh Kumar recorded 17 resident bulls, but we recorded only 5 bulls, two of which died later. Also suggesting to the decline are the mortalities of 74 elephants reported from 1991 to 2008. There were also possibilities of unrecorded mortalities, especially in the adjoining Cauvery Wildlife Sanctuary, where the infamous elephant poacher Veerapan was active till 2004. He was reported to have been responsible for poaching around 200 tuskers in the southern Eastern Ghats areas (Sukumar 1989a).

Skewed Sex-Ratio: Besides a decline in population, the sightings show a skewed sex ratio in favour of females, again suggesting to poaching pressures on tuskers. Analysis of the records of herds sighted and photographed revealed very few males (*c.* 15%) in the 5–15 age group; and only juveniles with small tusks were recorded in family herds.

Habitat Loss and Degradation: Ramesh Kumar (1994) attributed that the major cause for habitat degradation in Hosur-Dharmapuri was human exploitation of tree species. Our studies on biotic pressures and analysis of past and present forest cover through GIS also revealed the continuing loss of tree cover.The connectivity of this tract to Bannerghatta NP and the reserve forest of Kanakapura Forest Division in the northwest is almost lost with the existing corridors (Chattiramdoddi and Kempathahalli corridors) being only about 1.5 km wide (AERCC 1998). And, as mentioned earlier,

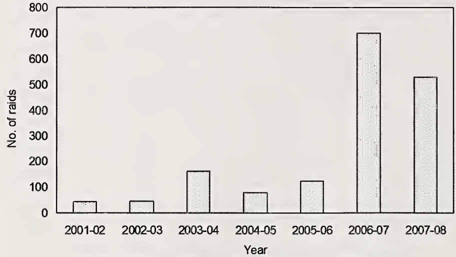

Fig. 8: Crop raiding in the Hosur-Dharmapuri area (2001–2008)

elephants have not been reported in the relatively open Hosur and Krishnagiri ranges for the past few decades. The pressures on the forest are from fringe and enclave villages, which depend on the forest for firewood and timber, minor forest produce, and grazing. Many of the tree (and shrub) species affected are the browse species of elephants. Illegal extraction of bamboo, a favourite food plant of elephants is also rampant. Ramesh Kumar (1994) had cautioned about the depletion of bamboo resources and its future adverse impact on elephants. Grazing pressure is severe leading to depletion of grass species, and the situation is further aggravated by the low rainfall in the region and the proliferation of the exotic shrub *Lantana camara*. Grass is an important component in the diet of elephants and could determine their movements in some areas (McKay 1973; Santiapillai *et al.* 2003; Sivaganesan and Johnsingh 1995; Sukumar 1989b, 1990; Sukumar and Ramesh 1995).

Proliferation of *Lantana camara*: The exotic weed *Lantana camara* occurs throughout the forest, and is especially more abundant in degraded forest and non-crystalline soil areas. Ramesh Kumar (1994) found the species to be widespread even during his study. The loss of native vegetation brought about by grazing and fuel-wood have facilitated its proliferation. Besides being of no food value to elephants, *Lantana* suppresses the growth of native species, including grass. Another negative impact of *Lantana* is that its wood is highly combustible and fires, especially those taking place after a gap of a few years, burn with greater intensity due to build-up of combustible material. Another invasive is *Prosopis chilensis*, but this species generally occurs only where the soil is loamy and around cattle pen areas, clearings, and at the outskirts of villages.

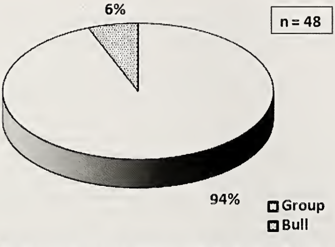

Fig. 9: Proportion of crop raiding by bulls and family herds in the Hosur-Dharmarpuri area (Nov. 2006 to Jan. 2007).

Decline of Preferred Food Species: Other than decline of food resources due to woodcutting, elephants are destructive feeders pushing down trees, breaking branches and debarking, thus killing them and opening up the canopy (Craig 1995; Guy 1989; Laws 1970; Wing and Buss 1970). Feral elephants have caused an alarming decline of some plant species in Interview Island (Andamans) and forming gaps and creation of secondary forest in the closed evergreen forest (Sivaganesan and Kumar 1995). Preferred food species are the first to decline. Ramesh Kumar (1994) found the density of *Ziziphus xylopyrus*, a preferred food plant of elephants, to be highest in the Rayakotta Range but also found use of the species by elephants to be heavy in the range. Vegetation sampling carried out by us over ranges (Daniel *et al.* 2008) revealed that the density of *Z. xylopyrus* is now extremely low in the Rayakotta Range, most probably due to elephant use over the years. *Z. xylopyrus* is highly preferred by elephants and was reported to have a 15% annual mortality rate in Mudumalai Wildlife Sanctuary (Tamil Nadu) due to elephant use (Daniel *et al.* 1995; Sivaganesan and Sathyanarayana 1995) and a decline was also reported in Koundinya Wildlife Sanctuary (Manakadan *et al.* 2010). Sivaganesan and Sathyanarayana (1995) also recorded serious declines in other preferred tree species in Mudumalai. Another species that had been nearly wiped out in Mudumalai is *Boswellia serrata*, which is now confined to the inaccessible hills of the Moyar Gorge (Daniel *et al.* 1987).

Fire: We recorded fire incidences in five ranges during summer, including a major fire in the Jawalagiri Range. Fire is cited to be beneficial in tall grass situations that offer poor dry season grazing for herbivores, which also benefits elephants (Santiapillai *et al.* 1995; Sukumar 1990; Sukumar and Ramesh 1995). However, fire also results in the dominance of fire resistant species (Guy 1989; Sukumar 1990; Sukumar and Ramesh 1995), which may not be palatable to elephants. The role of fire (especially in combination with elephant depredations) in converting woodland into open savannah is well-known (Craig 1995; Guy 1989; Laws 1970; Wing and Buss 1970). Considering the overall scarcity of grass and the other biotic pressures in HDRF, fire is expected to further stress the habitat impacting food availability for elephants.

Human Disturbances: Other than disturbance from woodcutters and graziers entering the forest on a daily basis, there is regular movement of people on the roads and paths leading to enclave and bordering villages. Another major disturbance is the 24-hour traffic on the Pennagaram-Hogenakal road to the Hogenakal waterfall, an important tourist spot. There are also a number of small temples in the forest which attract significant tourist traffic. Besides the disturbances, a lot of garbage gets generated by the tourists and pilgrims.

Crop Raiding: Even though the Hosur-Dharmapuri forest tract covers a large area (2,056 sq. km), it has a convoluted boundary with several projections and indentations, besides having numerous small and large village enclaves within its expanse. Such conditions increase the interface of forest with agriculture and human habitation areas, thereby resulting in a higher degree of crop raiding. Crop raiding is reported to have been not acute in the past but reached critical levels during the 1980s and early 1990s (Ramesh Kumar 1994). Comparison of the intensity of crop-raiding during this and the earlier study is not really possible due to the differences in the time frame and nature of the two studies. The data available with the Forest Department is also not totally reliable as except for human deaths (and to a lesser degree elephant deaths), reporting of claims, cases registered and compensation amounts given is dependent on many factors. However, our studies revealed that crop raiding is widespread all over the two divisions. Ramesh Kumar found the frequency of raids between solitary bulls and family herds to be about the same. Findings of most studies show that bulls raid crops more frequently (Balasubramanian *et al.* 1995; Datye and Bhagwat 1995; Daniel *et al.* 1995; Sukumar 1986b). Significant reduction of HEC on removal of bulls has been documented in Karnataka (Appaya 1992) and Koundinya Wildlife Sanctuary (Manakadan *et al.* 2009), suggesting that bulls were the primary crop raiders in those sites. However, family herds were found to be the main crop raiders in Hosur-Dharmapuri during this study. The reason for this, besides the decline in bull population, is probably habitat loss and degradation, making them more dependent on crop fields for food. This dependency compels family herds to take the risk of raiding crops inspite of the presence of calves.

CONCLUSION

The Eastern Ghats support the last tracts of forests and wildlife of the eastern Indian Peninsula. Even these are facing serious threats due to the pressures of the growing human population (Krishna Raju and Reddi 1990; Price 1977; Pulliah 2002) affecting elephant populations (AERCC 1998; Daniel *et al.* 1995; 2006, 2008; Manakadan *et al.* 2010; Ramesh Kumar 1994; Srivastava 2002; Sukumar 1986a, b; Sukumar 1989a, b). Ramesh Kumar (1994) had found the situation of elephants and their habitat in Hosur-Dharmapuri to be threatened even in the late 1980s and early 1990s. Things have further worsened judging from the high mortality of elephants, increase in crop raiding by family herds, and the continuing severe pressures facing the habitat as reported in this study.

The forests and elephants of Hosur-Dharmapuri reserve forests face threats from heavy livestock grazing, competition for water resources, woodcutting, exploitation of bamboo, collection of minor forest produce, proliferation of the invasive *Lantana camara*, outbreaks of fire, increase in road network and traffic, among others, also resulting in severe levels of HEC. Besides local threats, Hosur-Dharmapuri face external threats due to its proximity to the towns of Bengaluru (=Bangalore), Hosur, Dharmapuri, and Krishnagiri. During surveys, we recorded around 70 (fuel-wood based) brick kilns in the area with a concentration in the Jawalagiri Range. These mainly cater to the construction boom happening in Bengaluru and elsewhere. The pressures will only increase in the coming years with growing human populations both in rural areas and nearby towns. The human population of the former undivided Dharmapuri district has risen by 16.7% since 1991 and has now a density of *c.* 297 individuals/sq. km. Krishnagiri and Hosur are two large towns in Krishnagiri district, while Dharmapuri is the main town in Dharmapuri district. Hosur, which was earlier a village, has developed into a busy industrial town and manufacturing base for major Indian companies with a population of about 84,000 people. The metropolis of Bengaluru, 40 km from Hosur, is expanding rapidly. The human population of Bengaluru is now around 6.5 million, having grown by 34.8% during the last ten years.

Considering all these, there is an urgent need to tackle the conservation issues facing the forest and its elephants, or there will be further exodus of elephants out of the area, as witnessed during the 1980s. The conservation initiative in Hosur-Dharmapuri has to be essentially linked to the rest of the contiguous tract of the southern Eastern Ghats ranges, as the establishment of large and contiguous protected areas is crucial for the long-term survival of wildlife (see Johnsingh *et al.* 2010) and especially elephants which have a large home range. The adjoining forest divisions of this region face threats of their own and these forests are gradually getting degraded and fragmented due to various developmental activities and biotic pressures (AERCC 1998). Hence, it is vital that the forest integrity and habitat quality over this entire tract is ensured for the overall survival of elephants and that each site is not looked at in isolation.

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REVIEWS

1. SEA TURTLES OF INDIA: A COMPREHENSIVE FIELD GUIDE TO RESEARCH, MONITORING AND CONSERVATION, Compiled by: S. Shenoy, T. Berlie and K. Shanker. Published by: Dakshin Foundation, Bengaluru, and Madras Crocodile Bank Trust, Mamallapuram, 2011. 148 pp. Size: 15.5 cm x 21.5 cm, Paperback. Price not mentioned.

Sea turtles have always intrigued man. A picture of grace and beauty while in the sea, the females transform into helpless and ponderous giants when they come ashore on beaches to lay their eggs. The males are destined to forsake land forever after scampering into the sea as nestlings. The nearest they get a glimpse of land again is while off the nesting beaches for courtship and mating. Mainly threatened by man and other terrestrial predators during nesting, and some hunting at sea (by some communities; overall rare in India), turtles now face a serious threat through accidental catches in fishing gear, especially during *arribadas* (mass nesting of turtles), as in the case of the well-known *arribadas* in Gahirmata, Devi river mouth and Rushikulya in Orissa. Five of the seven species of marine turtles of the world are found in Indian waters: Loggerhead *Caretta caretta*, Leatherback *Dermochelys coriacea*, Olive Ridley *Lepidochelys olivacea*, Green *Chelonia mydas*, and Hawksbill *Eretmochelys imbricata*. The other species of sea turtles of the world are Kemp's Ridley *Lepidochelys kempii*, Australian Flatback *Natator depressus*, and East Pacific Green Turtle *Chelonia agassizii* (regarded as a race of *Chelonia mydas* by some taxonomists).

I had some experience of working on sea turtles, while based in Sriharikota Island during an Indian Space Research Institute (ISRO) funded project documenting the Island's faunal diversity. Around 200–300 Olive Ridley nested along the stretch of beach of the Island from January to March each year. Problems faced by the nesting turtles were predation by jackals and wild pigs, some cases of poaching by tribal Yanadis, deaths from drowning in the nets of trawlers, the growth of casuarina plantations at the borders of the beach encroaching on nesting sites, and illumination along roads and buildings on the shore that can disorient hatchlings to head for land instead of the sea. These are largely the problems of sea turtles that inhabit Indian waters – and must be facing in the rest of the world.

The threats to sea turtles have fortunately resulted in an explosion of studies, attention, and conservation efforts for them, this manual being a good example. The publication is a combined revised edition of two earlier publications brought out by the Madras Crocodile Bank Trust in 2003 under the GOI-UNDP Sea Turtle Project, with additional inputs from other publications. One gets, in a nutshell, all the required information necessary to undertake research, monitoring and conservation of sea turtles. Regarding production aspects there is hardly anything to pick on. It is of small and handy size (easy to carry in the field or perused lying down!), does not involve wastage of paper (page space fully exploited) or squander precious conservation money (e.g., most photos are in black and white), and the text and illustrations are crisp and neat. The only thing I found jarring were the two-page introductory write-ups to chapters with startling large font size and liberal line spacing. These, I feel, can be skipped, and instead, be suitably incorporated into their respective chapters – maybe in the next edition/reprint.

The manual has three main chapters or sections: Introduction, Research and Monitoring, and Conservation and Management. One gets to know all about Indian sea turtles in the first chapter, their identification based on morphological characteristics and from the tracks left on beaches by nesting females; their biology, life history, habits and habitat, and distribution. The second chapter (Research and Monitoring) describes methodologies to study sea turtles: beach surveys and data collection at nests, biometric studies, tagging for individual identification, population estimation, studying movements and migration, satellite tracking, use of equipment, genetic studies, and habitat assessment. Information that needs to find a place in the next edition (in page 72 of this edition), would be on the reported average number of clutches laid by females of different turtle species during a nesting season, so that one need not search other publications for this information to estimate population size of nesting turtles at a site. Some of the threats facing sea turtles and ways to mitigate them discussed under Conservation and Management, make interesting reading and will be of much use for personnel involved in sea turtle conservation. There is also a section containing sample data sheets for recording information on turtles at beaches, namely nesting females, carcasses, nests, profile of nesting sites, and concerning hatcheries. This is followed by a bibliography, glossary and a list of organizations in India that are engaged in conservation of sea turtles in India.

Overall, this is a neat publication and essential reading for researchers and conservationists working on sea turtles. It is mainly intended for free distribution to such people or institutions, and can be made available to others free on request.

■ RANJIT MANAKADAN

2. TRIPWIRE FOR A TIGER: SELECTED WORKS OF F.W. CHAMPION, Compiled by James Champion. Published by: Rainfed Books, Chennai, 2012. 202 pp. Size: 14 cm x 21.5 cm, Paperback. Rs. 495/-.

"I had lost all desire to kill wild animals. Not that this has proved any loss to me because I have found that wildlife photography provides all the thrills and excitement of hunting without having to shed any blood at all ... Such pictures hanging on one's walls in subsequent years, bring back vividly, as no skin or head can ever do, what may have been the most thrilling moments of one's life. Surely, looking at the photographs, one can half close one's eyes and feel again the warm air and hear the hum of the insects; one can see the shifting sunlight as the mid-day breeze stirs the leaves and throws the tiger into alternate light and shade; and, lastly, one can see the living, breathing tiger as he lies, having no final vision of the magnificent king of the jungle lying in death agony or mar the pleasure of a wonderful experience". Excerpted from the last chapter of the book under review.

The above quote is from a especial text written by Fredrick Walter Champion (FWC) on the centenary of the Forest Research Institute, Dehradun in 1961. Though his hosts would have expected him to write about forestry *per se*, FWC deliberately chose *"not to write about the scientific side of forestry"* but rather about the denizens of the Indian jungle and their conservation needs, which according to him, must be integral to the basic precepts of the forestry paradigm and practices. Now who was FWC and why did India's Forest Research Institute pick on him for such a singular honour?

Well, he was simply a gifted and innovative, outdoors photographer who concurrently emerged as among the most distinguished gazetted officers of the Indian Forest Service (IFS), from 1923 to 1947. Within the first ten years of service, he had won recognition among his peers and the world at large, as the undisputed pioneer of wildlife photography in India, and the first to successfully pursue free-ranging tigers armed with a camera in preference to a sporting-rifle in their natural habitat. Equally, FWC's powers of descriptive prose were so acute, refined and mesmerising that his text and supporting photo-images found ready acceptance with prestigious publications, such as *The Illustrated London News* as also by the two most exclusive outdoors magazines, *The Field and Country Life*. With just four years' service, FWC published his first book, WITH A CAMERA IN TIGER-LAND (Chatto and Windus, London 1927). The book was received most enthusiastically, and by all counts, ~~it~~ was a great achievement considering that both photography and writing were merely FWC's persuasions on the sidelines of a demanding profession, where he is remembered for distinguished and substantive achievements.

TRIPWIRE FOR A TIGER is an anthology comprising 24 published articles by FWC (including one from the *JBNHS*, 1926/7?), selected and chronologically arranged by his doting grandson, James Champion, after visiting India in 2006 for a first-hand authentication of places and perspectives covered in the texts. Little wonder, therefore, that the book stands out as a rare, 24 years long celebration of the ways of the Tiger and most other denizens of the jungles as photographed, described and witnessed by FWC, in the then Lansdowne Forest Division, in today's Uttarakhand State.

Remarkable as those images of the Tiger were for the sheer novelty of the endeavour, the demanding photographer in FWC was quick to notice two technical blemishes, arising from the uncontrolled effects of sunlight and shadows upon the subject, and the inevitable "camera-shake" induced by Balmati's (his favourite elephant) breathing rhythm. It was, therefore, a natural next step for FWC to ensure a rigid mount for the camera, induce the tiger to a pre-focused spot using a bait, and lastly, but most importantly, to innovate a light-flash of sufficient intensity to fire synchronously with the camera shutter-release for capturing true to life imagery. And this is what led to the use of tripwire as the trigger in FWC's innovation, which in today's parlance and usage is termed as 'camera-trap'. However, FWC's elementary flash-light was inefficient, but fortunately, just then Mr. Nesbit of New York patented a flash apparatus and FWC acquired one, at once. Simple as his plan of action might appear, the failures-riddled path is best described in FWC's words:

"I have arranged my apparatus perhaps 150 times in this way, and (sic *in four years) I have had a tiger pass only six times.* Four times the flashlight was fired, the fifth time the tiger saw the trip-wire and stepped carefully over it and the sixth time the wire broke without completing the electric circuit. *Of the four times the flashlight was fired, once the shutter failed to work and another time the tiger found the wire and took it in his mouth ... Of the remaining two exposures, one shows the tiger going away and the other is I consider, the best photograph I have ever obtained."* In my opinion, even in today's digital-cameras world, that black and white image will rank for all times among the best of the best tiger photographs. Jim Corbett is on record that he took to tiger-photography on seeing FWC's inimitable creations.

Perhaps the best testimony to FWC as a writer and naturalist lies firmly embedded in one of his earliest texts – A REMARKABLE "SITTING" BY A WILD TIGER, published in the *Illustrated London News* on July 24, 1926, which appears as the first chapter in the book under review. In the course of his duty, FWC had learnt of several ways to intercept tigers (so to speak), both while on their nocturnal hunts as also in their diurnal lairs! So taking a day off once, he had mounted on his favourite elephant Balmati in the company of his wife Judy, when shortly before mid-day, Judy nudged FWC to indicate a tiger which sighting provided the following timeless description, more vivid than any visual can ever be:

"He lay, twelve yards away from us, with his mouth open, his sides heaving, yawning occasionally, sometime rolling right over on his side and sometime holding his head up, until his eyes began gradually to close with sleep. Every now and then he opened his eyes and looked at us, but always came to the conclusion that we were harmless, if somewhat boring, intruders who were disturbing his afternoon nap. He stayed there for perhaps a quarter of an hour, during which time we exposed all the Plates we had, gradually going closer and closer until the last Plate was exposed at a little under ten yards range ... One simple shot, and all the life and movement would have gone from that beautiful striped body and could never be brought back again." FWC was never to falter from that latter conviction. For sure, not all ventures were as peaceful because there were at least two occasions (once with a tusker and another an enraged tiger), when the thought uppermost with FWC was *"how will I face my father-in-law should their only child come to harm!"*

Lest the reader be misled that FWC was exclusively tiger-centric, let me state that the book is a rich repository of the varied riches of our living jungles, from elephants to squirrels, Indian Wild Dog to vultures, Leopard to Blackbuck, Sloth Bear to butterflies and so on. Even more significant is the message that emerges from each text that wildlife and their habitats are among our beautiful heritage, which we must preserve. And in the context of our times, when the Tiger is prized explicitly for its skin, whiskers, flesh, claws, and bones, the book will be an invaluable motivator in the hands of both the young and old. Besides, there are two illustrations in the book which deserve to be pointed out. The frontispiece carries a charcoal portrait of Balmati and her mahout Karim Baksh, so riveting that one simply cannot have enough of it. In addition, each chapter closes with the image of a tiny perched bird, a Coal Tit which FWC photographed at age 17 which enriched his pocket-money by six shillings, in prize money!

We Indians shall remain indebted to FWC for his pioneering and persuasive advocacy of creating National Parks in India (similar to those in the USA and South Africa), which led first to the enactment of National Parks Act of 1935, and a year later, the creation of the Hailey National Park, today's prestigious Corbett Tiger Reserve. None of this may have been possible but for the enthusiastic support of the visionary Governor of the United Province, Sir Malcolm Hailey. The latter then became the Viceroy of India, which was a fateful conjunction of lucky stars for India's wildlife.

■ LT. GEN.(RETD.) BALJIT SINGH

3. MARINE MAMMAL SPECIES OF INDIA by E. Vivekanandan and R. Jeyabaskaran. Published by Central Marine Fisheries Research Institute (ICAR), Kochi, 2012. 228 pp. Size: 24 cm x 17 cm, Hardbound. Price not mentioned.

The activities of the Central Marine Fisheries Research Institute (CMFRI), as the name suggests, are related to monitoring, developing, and exploiting marine fisheries resources. Although marine mammals do not fall within this scope, the CMFRI has gathered much information on this group of animals over the years. This information, until recently, was primarily related to whale and dugong strandings, and to non-targeted catches of dolphins and finless porpoises by fisheries.

Recently, CMFRI completed a more active effort to study marine mammals. It surveyed parts of the Indian Ocean, and associated seas, through a series of cruises. And now the organization has produced the book under review. The stated objective of this work is to 'create interest and awareness among students, researchers, naturalists, and conservationists on marine mammals occurring in the Indian seas'.

Accounts of 26 species, constituting a section named 'Species Profile', make up the major part of the book. A brief introduction and a nine-page chapter titled 'Distribution of Cetaceans in the Indian EEZ and Contiguous Seas' precede this section. A chapter, also brief, titled 'Future Directions' ends the main text of the book.

The chapter on the distribution of cetaceans in the Indian EEZ is not a comprehensive review as one expects from the title, but is devoted to the findings of the CMFRI's marine mammal survey. Notwithstanding this, it is a significant component of the book because it is essentially a presentation of the findings of this extended survey, which were not available outside CMFRI. In this section, the authors have listed the species observed by them (from October 2003 to November 2011), along with details of abundance. They have determined the 'productivity' of each month of the year — that of February, with 1.01 sightings per day, was highest, while August was least rewarding, with 0.02 sightings per day. The authors have also related their sightings data to water depth, sea surface temperature, and water salinity. All this is valuable information. The spatial distribution of the sightings is not presented in this section. This appears to be a serious omission because the overriding question in one's mind then is "where in our seas are marine mammals found?" As it happens, species-wise maps are provided for the cetacean surveys during 2003–2011, but in the next section.

In the set of species accounts, the authors have included only marine mammal species that have been recorded from India. A few other species have been recorded from the waters of adjacent countries and may be expected to be found in India in the future, but these have been excluded. The authors explain that they have not included the Sei Whale, which has been recorded a number of times in India, because these records have been shown to be misidentifications. But curiously, at the same time, they have included the Fin Whale. This species too has been recorded many times in Indian waters, but some scientists pointed out that none of the records from the entire northern Indian Ocean are really verifiable.

The species accounts provide information under the following heads: taxonomy, common names, identification characters, distribution, abundance, habitat, behaviour, food, exploitation and threats, and conservation status. A table of stranding and sighting records from India has been provided for each species. And under the respective species accounts are the aforesaid maps. With the maps in their present locations, all known records (those of the CMFRI survey as well as past records of other observers) could have been marked on them.

The species accounts and the book in general are profusely illustrated with colour photographs. They lend a certain deep blue theme to the volume. A number of the pictures give rise to a feeling that they have been digitally enhanced somewhat enthusiastically. There is something 'flat' about the Dugong on the beach on p. 177. The Dwarf Sperm Whales on pp. 71 and 73 appear identical, although the one seems to be lying on a sandy stretch and the other is in some other situation. Similarly, the Pygmy Killer Whale on p. 89 is uncannily like the one on p. 91.

The chapter on future directions recommends that a marine mammal stranding network be set up in India. Efforts to achieve this have been continuing for some years, starting with a workshop that was conducted at the CMFRI. The chapter also recommends that a marine mammal conservation network and a database devoted to marine mammals be created. These have been in existence for five years.

Much effort has gone into making this book suited also for popular reading. It is hard bound and well-produced. It will be of interest to the more technically inclined naturalist. The CMFRI could bring out such publications on other groups of animals as well.

■ KUMARAN SATHASIVAM

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MISCELLANEOUS NOTES

1. PHOTOGRAPHIC RECORD OF A MELANISTIC SPOTTED DEER *AXIS AXIS* (ERXLEBEN) IN PARAMBIKULAM TIGER RESERVE, KERALA, INDIA

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In July 2009, while on patrol duty from the Kerala Forest department's boat in Parambikulam Wildlife Sanctuary, I sighted a herd of Spotted Deer *Axis axis* along the shore of the reservoir. Suddenly, I spotted a very dark animal in the herd, which seemed to be dominant and 'leading' the herd. Without wasting time much time, I took out and used the longest possible zoom lens to have a close-up view of the animal, and saw that it resembled a Spotted Deer except for its jet black coat colour. I managed to take a few photographs of it till it retreated back into bamboo thickets.

Later, while enlarging the images in the camera, I could see the typical spots of a Spotted Deer hidden under the black coat of the animal. This is perhaps the first (photographic) record of a melanistic Spotted Deer in the wild.

2. SUNBASKING BEHAVIOUR OF ELLIOT'S GIANT FLYING SQUIRREL *PETAURISTA PHILIPPENSIS* (ELLIOT) IN SITAMATA WILDLIFE SANCTUARY, RAJASTHAN, INDIA

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The Elliot's Giant Flying Squirrel *Petaurista philippensis* (Elliot), a nocturnal species is distributed in the southern and some western states of India (Nandini 2001a, b; Prater 1971). The species has been studied by Bhatnagar *et al.* (2010a, b), Chundawat *et al.* (2002), Koli *et al.* (2011), Sharma (2007), and Tehsin (1980) in Rajasthan. However, these authors have not reported sun basking in this species. In this note, we report sun basking behaviour observed in the species in Sitamata Wildlife Sanctuary.

Sitamata Wildlife Sanctuary (24° 04'–24° 23' N; 74° 25'–74° 40' E) is situated in Pratapgarh district of Rajasthan state. Teak is the dominant tree species in the Sanctuary, but the valleys have Mahuwa *Madhuca indica*, Charoli *Buchanania lanzan*, Shadad *Terminalia tomentosa*, Bahera *T. bellirica*, and Mango *Mangifera indica*. In winter, the temperature in Sitamata Wildlife Sanctuary drops to as low as 4 °C. Terrain of the Sanctuary is hilly and rugged with a number of deep valleys and gorges. Due to the low temperature, the air becomes chilled and heavy and accumulates in the deepest parts of the valleys or at ground level. Frost is not uncommon in the area, especially during mid-December to mid-February.

The valley groves of Mahuwa in Sitamata Wildlife Sanctuary are commonly inhabited by the Elliot's Giant Flying Squirrel *Petaurista philippensis* (Elliot) (Koli 2012; Sharma 2007).

On January 12, 2012, at about 11:00 hrs, while studying the biodiversity of Sitamata Wildlife Sanctuary near Arampura forest outpost, we saw a basking flying squirrel clinging on a nearly horizontal well-lighted thick branch of a Mahuwa tree. It was motionless in the flat posture keeping its dorsa exposed to the sun. The same behaviour was noticed again on January 13, 2012. Being nocturnal, the Elliot's Giant Flying Squirrel retires into its hollows before sunrise. However, since they probably feel the discomfort of low temperature in the hollows due to the presence of chilled air, the squirrels sometimes peep out to take warmth of the sun as the air becomes warm. Sometimes, they completely emerge and settle down on a bough, to bask in the sunlight. Their black dorsum helps them to absorb the heat of the sun. The Elliot's Giant Flying Squirrel has been reported resting outside its hollows during hot days in summer in Rajasthan (Bhatnagar *et al.* 2010b), but there have been no reports of basking in the sun in winter till our record. Sun basking in winter is known in the Five-striped Palm Squirrel *Funambulus pennantii*. Sitamata WLS has thick forest sanctuary and very less quantum of light reaches on ground in the valley during the day. Thus, temperature remains low not only during the night but also during the day, especially during winter. Hence, the low temperature conditions compel this nocturnal animal to emerge from its hollow for thermoregulation through basking.

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3. USE OF PALM FRONDS FOR NEST SITES BY THE NORTHERN PALM SQUIRREL *FUNAMBULUS PENNANTII* WROUGHTON

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The Northern Palm Squirrel *Funambulus pennantii* Wroughton is a common squirrel in northern India (Gurung and Singh 1996; Menon 2003; Prakash 1994). At night, it takes shelter in small cavities in trees, crevices in walls, and sometimes uses letter boxes and electric meter boxes in houses (Prakash 1994). The female prefers tree holes and cavities in walls for placing nests (Roberts 1997).

However, on June 5, 2008, I recorded an active nest of *F. pennantii* placed on the upper surface of a slanting frond of a Chinese Palm *Livistona chinensis* (Fig. 1) in Gulab Bagh Zoo, Udaipur. The to and fro movements of the female were visible, and also the vocalization of the infants. The nest was cylindrical with a tapering entrance, the shape due to conduplication of the palm leaf which resulted in an open tunnel-like space in the middle of the fan-like frond of the palm. Conduplication is a natural 'folding' in palm leaves which provide space for nesting. The cavity formed by conduplication was occupied by the squirrel for her nest.

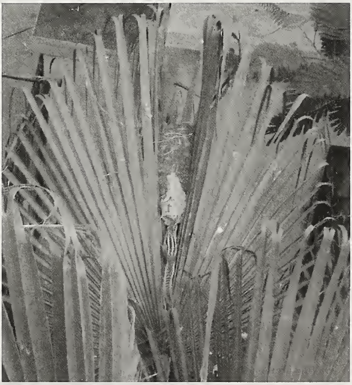

Fig. 1: A female Northern Palm Squirrel close to her epifoliar nest

Besides the nest, an old nest (probably of the previous year) was also present on another frond of the same tree. These two records show that the Northern Palm Squirrel also makes nests in fronds of palms, other than those reported in cavities in trees, buildings, among others.

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The author is thankful to the officials of the Forest Department, Rajasthan, for providing facilities during the visit to the zoo.

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4. PREDATION ON NORTHERN HOUSE GECKO *HEMIDACTYLUS FLAVIVIRIDIS* RÜPPELL BY FEMALE NORTHERN PALM SQUIRREL *FUNAMBULUS PENNANTII* WROUGHTON

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The Northern Palm Squirrel *Funambulus pennantii* Wroughton is a common squirrel in northern India and is commensal to man (Prater 2005). On April 25, 2012, we observed a Northern Palm Squirrel struggling with a Northern House Gecko *Hemidactylus flaviviridis* on a *durry* (sort of carpet) spread in the playground of a college in Jaisalmer, Rajasthan.

To get a better look, we quickly went closer, and were surprised to see that the squirrel had overpowered and killed the lizard by that time. The autotomized tail lying slightly away from the site, and the squirrel was eating the lizard from the end of the broken tail. On being disturbed by us, it carried away the gecko, climbed a chair, and continued feeding on it. Almost all the fleshy parts, ribs and bones of the limbs, except the digestive tract, some bones of vertebral column and parts of the skull were eaten away by the squirrel. The squirrel left after eating the prey. The whole event was over within ten minutes.

Later, we followed the squirrel and found that it was engaged in nest building, and that it was a female with a large abdomen, probably in an advanced stage of pregnancy.

The Northern Palm Squirrel is generally considered a herbivorous rodent that feeds on fruits, seeds, leaves, etc. However, the females of rodents require protein and mineral rich food during their breeding season (Challahan 1993; Mattingly and McClure 1982; Payne and Wheeler 1968; Veloso and Bozinovic 2000). Meat eating by ground-dwelling squirrels is a well established fact (Bailey 1923; Friggen 2002; Morgart 1985; Packard 1958; Wistrand 1972). Some studies have also shown that pregnant and lactating squirrels feed on bones to fulfill their requirement of calcium and phosphorus (Carlson 1940; Coventry 1940). *Funambulus pennantii* is also reported to kill and eat birds (Tiwari 1990). Thus, requirement of protein must have caused this large herbivore to feed on the lizard.

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5. PROBABLE FIRST SIGHTING OF DARK MORPH OF EASTERN CATTLE-EGRET *BUBULCUS COROMANDUS* FROM LAKHIMPUR KHERI, UTTAR PRADESH, INDIA

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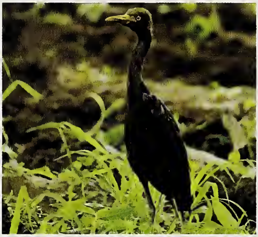
I spotted a dark morph of Eastern Cattle-Egret *Bubulcus coromandus* on June 22, 2011, at Alinagar village, Lakhimpur Kheri, Uttar Pradesh, India. It behaved like the normal birds, but did not 'socialise' with them. At first sight, it appeared that the bird was soiled as it was the rainy season. But after careful observations for more than two months, I confirmed that its dark coloration was true. Had the dark colour not been a case of hyper-pigmentation, it would either have been washed off or faded by that time. I did not visit the place after that.

This is probably the first record of what could be a dark morph or aberrant form of the Eastern Cattle-Egret.



Eastern Cattle-Egret *Bubulcus coromandus*

6. NEW RECORD OF COMMON COOT *FULICA ATRA* LINNAEUS, 1758 FROM ANDAMAN AND NICOBAR ISLANDS, INDIA

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The Andaman and Nicobar archipelago comprises of 572 islands, extending over 800 km and running north to south between 6° 45' N and 13° 30' N, and between 90° 20' E and 93° 56' E with extent of 8,249 sq. km.

The study on birds of Andaman and Nicobar Islands was initiated by Beavan (1867) listing the avifauna of Andaman Islands, followed by Hume (1873, 1874 a, b, 1876), Abdulali (1964, 1965, 1967, 1971, 1979, 1981). Recently, a few researchers have contributed to the avifauna of Andaman and Nicobar Islands (Chandra and Kumar 1994; Ezhilarsi and Vijayan 2006; Kailash and Rajan 1994; Pande *et al.* 2007; Sankaran 1995, 1998, 2001; Sankaran and Vijayan 1993; Sivakumar 2007; Sivakumar and Sankaran 2002; Sivaperuman *et al.* 2010; Tikader 1984; Vijayan 1996, 2007; Yahya and Zarri 2003; Yoganand and Davidar 2000).

As part of major ecological studies on wetland birds of south Andamans initiated during 2012, and sponsored by the Science Engineering Research Board (SERB), Department of Science and Technology, New Delhi, we have been surveying the area regularly. During these surveys, seven individuals of Common Coot *Fulica atra* were recorded in the tsunami inundated wetlands at Sippighat, South

Andaman (11° 36' N; 92° 41.46' E) on October 13, 2012, along with 122 Lesser Whistling-Teal *Dendrocygna javanica*, 24 Purple Moorhen *Porphyrio porphyrio*, 6 Cotton Teal *Nettapus coromandelianus* and 12 Common Moorhen *Gallinula chloropus*. The birds were again sighted on October 14 and 15, 2012 in the same location. All the coots were adults.

The Common Coot is resident and winter migrant and widely distributed all over India, breeding on freshwater lakes and ponds up to 2,500 m in the Himalaya in India and Central and South Asia, Pakistan, Nepal, Bangladesh and Sri Lanka (Ali and Ripley 1983; Arun Kumar *et al.* 2005). Review of literature revealed that it has not been reported from Andaman and Nicobar Islands, and hence, this is the first report of the species from Andaman and Nicobar Islands.

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7. SIGHTING OF GREY-HEADED LAPWING *VANELLUS CINEREUS* AT HARIPURA RESERVOIR IN UTTARAKHAND, INDIA

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Grey-headed Lapwing *Vanellus cinereus* breeds in NE Asia and winters in the northern parts of Southeast Asia (Piersma 1996). The species is under-surveyed with no exact estimation of population size existing than the broad range of 25,000–100,000 mature individuals in the world (Wetlands International 2006). Grey-headed Lapwing *Vanellus cinereus* appears to have a decreasing population trend (BirdLife International 2012), but the decline is not very rapid. The species has an extremely large range and is listed as 'Least Concern' in the IUCN Red List of Threatened Species (2011).

It is an uncommon winter migrant in India (Kumar *et al.* 2003), and its major wintering grounds are in the north-eastern part of the country (Grimmett *et al.* 1999; Lanier 2004), while individual records of sightings are reported from various other regions such as Bharatpur in Rajasthan (Grubh 1968), Kodigehalli in Karnataka (Subramanya 1987), Goa (Lainer 1991, 2004), Namdapha Tiger Reserve in Arunachal Pradesh (Barua 1999), Pallikaranai, Kaliveli, and Point Calimere in Tamil Nadu (Santharam 2003; Sundar 2000), Thrissur district in Kerala (Ravindran and Nameer 2001; Ravindran 2004), Thatipudi Reservoir and Machilipatnam in Andhra Pradesh (Conoy 2003; Pittie 2001), Pobitora Wildlife Sanctuary in Assam (Barua 2001), Chilika (Balachandran *et al.* 2005) and Bhitarkanika (Gopi and Pandav 2007) wetlands in Orissa and Sunderbans in West Bengal (Zöckler *et al.* 2005). In recent years, the species has also been reported from the Kaluste-Bhile Kharland area in Konkan (Palkar 2010) and from Trishna National Park and Wildlife Sanctuary, Gumti Lake, and Sepahijala National Park in Tripura (Choudhury 2010). These are the first records of Grey-headed Lapwing from Konkan and Tripura. There have been frequent sightings reported from coastal Tamil Nadu in recent years (Santharam *et al.* 2006). This bird is mainly found along muddy river banks, marshes and wet fields (Grimmett *et al.* 1999; Kazmierczak 2000).

The Corbett Foundation (TCF) has been carrying out a regular waterfowl census programme, since 2001, in selected wetlands located in the Corbett landscape to estimate the population of migratory birds (Bhattacharjee and Bargali 2012). As part of this programme, Haripura Reservoir (29° 06' N; 79° 20' E), on Baur river, located in Terai Central Territorial Forest Division of Uttarakhand, is being monitored fortnightly by the Wildlife Division of TCF during winter. On December 02, 2011, at about 10:55 hrs, the first author spotted a Grey-headed Lapwing among other Lapwing species, such as Red-wattled Lapwing *Vanellus indicus* and White-tailed Lapwing *Vanellus leucurus*, in a marshy part of the wetland. It was easily distinguished from the other lapwings by its grey head, yellow bill with black tip, as well as the prominent black breast and tail bands. During the subsequent waterfowl census carried out at Haripura Reservoir on December 17, 2011, two Grey-headed Lapwings were recorded from the area. Grey-headed Lapwing was first recorded by TCF wildlife division from Haripura in 2009. It is the first record of this species from the State of Uttarakhand (Director, ZSI 1995, 2008).

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8. RANGE EXTENSION OF ORANGE-BREASTED GREEN-PIGEON *TRERON BICINCTUS* (JERDON 1840) – FIRST RECORD FROM MAHARASHTRA, INDIA

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The distribution of the Orange-breasted Green-Pigeon *Treron bicinctus* in the Indian subcontinent is the lower Himalaya from the Uttar Pradesh *terai* and Nepal to Arunachal Pradesh and Bangladesh, Eastern Ghats, southern Western Ghats south of Goa and Belgaum, and Sri Lanka. It has also been recently reported from Sriharikota Island, Nellore district, Andhra Pradesh (Manakadan *et al.* 2009, 2011). There have been no records of the species in Maharashtra (Prasad 2003) and in northern Western Ghats (Ali 2002; Grimmett *et al.* 2011; Kazmierczak 2000; Manakadan *et al.* 2011). In this note we report occurrence of the Orange-breasted Green-Pigeon in the northern Western Ghats in Kolhapur, which is the first record of the species in Maharashtra

On February 12, 2012, at 06:00 hrs, we were on the way towards Tudiye and Mahalunge forest in Chandgad tehsil of Kolhapur district, Maharashtra for bird watching. We sighted a male Orange-breasted Green-Pigeon *Treron bicinctus* on a treetop at the outskirts of Shinoli village (15° 52' N; 74° 22' E), about 120 km from Kolhapur town. Later it flew off to disappear into the nearby forest. Unfortunately, we did not have a camera, but the bird was identified using field guides of Kazmierczak (2000) and Grimmett *et al.* (2011). The nearest record of the species to our recorded site (Shinoli) is Belgaum, which is *c.* 200 km to its south. Shinoli and Belgaum are located at *c.* 750 m above msl and have moist mixed deciduous and semi-evergreen mixed forest habitat. Subsequent to our record for Maharashtra, the species was photographed by Milind Valawalkar in Valawal village of Sindhudurg district, Maharashtra on April 16, 2012 (http://www.indianaturewatch.net, accessed on May 12, 2012).

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9. NEST MATERIAL KLEPTOPARASITISM BY SMALL SUNBIRD *NECTARINIA MINIMA* (SYKES, 1832)

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The Small Sunbird (*Nectarinia minima* Sykes, 1832) is endemic to the Western Ghats (Ali and Ripley 1987). It makes a typical pouch-like nest like other sunbirds, but the nest is smaller and more globular and suspended towards the end of horizontal branches of a tree or shrub. The nest is composed of fine plant fibres, small twigs, mosses, cobwebs, lichens, and soft seed hairs (Ali and Ripley 1987; Ali 1999; Hume 1890). Its nesting behaviour was described by Nayar (1934), but he did not report of thieving of nest material by the species and stated that only fresh material was used for nest construction. This note discusses the nest material piracy by a Small Sunbird from an active nest of Oriental White-eye *Zosterops palpebrosus* observed from the Silent Valley National Park (11° 04' – 11° 13' N; 76° 24' – 76° 29' E) in Kerala, India.

On February 23, 2010, at 14:26 hrs, a female Small Sunbird was found collecting the soft hair (pappus) of the seeds of *Asclepias curassavica* (Asclepiadaceae) growing in front of a camp shed in Silent Valley. In her third trip, she was accompanied by the male, but he did not collect nest material. The nest was located in a 2 m *Lantana* shrub towards a cliff. At about 16:10 hrs, she flew into the canopy of a 3 m *Glochidion* tree, *c.* 42 m from the nest. After a while, it came out from the canopy with a bunch of soft white hair in her beak. A close observation in the canopy showed a small cup-shaped nest placed on a forked branch. There was no bird in that nest and the sunbird must have taken the material from this nest as no such material was found in the canopy. After this incident, the bird continued to collect pappus from the plant for three times. Later, she again flew into the canopy of the tree but returned without carrying any nest material, and appeared anxious, probably since the nest was now occupied by an Oriental White-eye.

On the second day, I recorded her collecting pappus hairs 16 times and stealing nest material in 19 instances. In the second and ninth attempts, she was chased by the Oriental White-eye. After being chased off, she did not try stealing for the next one or more hours. On the third day, she stole lining material 12 times from 09:05–12:10 hrs. During this time, she collected pappus only three times. On a check in the evening, it was found that the nest was occupied by the White-eye. However, the next day, it appeared that the White-eye had abandoned its nest as it was severely damaged.

Nest material piracy is not uncommon in birds (see Ley *et al.* 1997; Narwade *et al.* 2005). Some of the reasons for nest material thieving are for saving time and energy in finding and transporting nest materials, low availability of suitable nest material and increased use of the same nest material by conspecifics and other birds in the nesting locality and decreased predation risk while collecting material from far off places (Jones *et al.* 2007; Ley *et al.* 1997). Nest failure and transfer of nest parasites may be some of the major disadvantages of species affected by nest material kleptoparasitism (Ley *et al.* 1997; VanderWerf 1988). In this reported case, the White-eye may have abandoned the nest due to the damage caused by the sunbird.

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10. NOTES ON SIGHTINGS OF GREEN AVADAVAT *AMANDAVA FORMOSA* IN A FEW LOCALITIES IN SOUTHERN ARAVALLIS, INDIA

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The Green Avadavat *Amandava formosa* is a threatened endemic and red data listed passerine species of India (Bhargava 1996; BirdLife International 2012). It is distributed mainly in Central India from Rajasthan (Mt. Abu) to Bihar and south Uttar Pradesh to north Andhra Pradesh (Manakadan *et al.* 2011). In Rajasthan, it has been mainly reported from the Mt. Abu area in Rajasthan (Lodhiya 1999; Tiwari and Varu 1999; Mehra and Sharma 2004). There is also a report of it as a resident species in the campus of the Desert Regional Station of the Zoological Survey of India in Jodhpur (Sivaperuman *et al.* 2004). In this paper, we report on our sightings of the species in other sites of Rajasthan, namely Kumbhalgarh, Kaler Forest Block, and Sajjangarh Wildlife Sanctuary.

Kumbhalgarh: Kumbhalgarh lies in Rajsamand district in southern Aravallis. It is an extensive hilly area. A largeportion of this hilly zone comes under Kumbhalgarh Wildlife Sanctuary, while the rest is being managed as territorial forest. Numerous patches of revenue lands and villages are scattered across Kumbhalgarh. Many small grasslands, locally called beeds or beedas, are scattered all over the Kumbhalgarh zone. The historical Kumbhalgarh fort is present in this zone, hence whole area is popularly known as 'Kumbhalgarh'.

We first recorded the Green Avadavat in the Kumbhalgarh area in 1986 in Oda village in a sugarcane field. Its distribution here is largely confined to the vicinity of sugarcane fields, scrub forests and rolling hilly grasslands. Sightings were relatively more in Kumbhalgarh area till 1990. Till then, sugarcane cultivation was common from Kumbhalgarh to Gogunda area, and the species was recorded in Kumbhalgarh, Losing, Sayra, and Gogunda areas. In recent years, with increasing aridity and receding ground water table, sugarcane cultivation has reduced drastically, and this has probably affected the population of the Green Avadavat, as according to Ali and Ripley (1983), the Green Avadavat prefers grass and low bushes, tall grassland, sugarcane fields and boulder-strewn jungle. During 1986, flocks of 10–25 birds were recorded, but now sightings are scarce and flocks of more than 7–8 birds are rarely seen.

Kaler Forest Block and Sajjangarh Wildlife Sanctuary: Sajjangarh is the smallest sanctuary of Rajasthan state, covering an area about 5.19 sq. km. It is present towards the western outskirts of Udaipur city in Udaipur district. Kaler Reserve Forest, west of the Sajjangarh Sanctuary, is contiguous with the sanctuary. Both the localities are situated nearly 80 km south of Kumbhalgarh. Sajjangarh and Kaler are part of southern Aravallis, with thorny and deciduous forests. The fringe area in both the localities has low density of trees. These fringes turn into rolling grasslands during the monsoon. Grass cover remains intact up to winter, but get grazed or destroyed by fires up to the beginning of summer. Kaler Forest Block and Sajjangarh Wildlife Sanctuary have a sparse jungle of short trees intermixed with grassy patches: *Apluda mutica*, *Sehima nervosum*, and *Heteropogon contortus*. *Acacia senegal*, *Prosopis juliflora*, *Boswellia serrata*, *Lantana camara*, *Grewia tanex*, *G. flavescens*, *Dichrostachys cinerea*, *Diospyros montana*, and *Capparis sepiaria* are found. These forests have a network of seasonal nallahs.

On being informed of the presence of Green Avadavat in the Kaler Forest Block by a forest guard, we visited the site on December 24, 2011, and saw a bird in the thicket of *Acacia senegal* and *Prosopis juliflora*. It was observed for about 8 minutes before it flew into the adjoining Sajjangarh Wildlife Sanctuary. The next day, we sighted three birds, which again flew into the Sajjangarh Wildlife Sanctuary. Two birds were seen on December 27 near a waterhole in the Gorella Beat of the Sanctuary by a forest guard (Sada Shiv Tiwari). We have visited the Kaler forest and Sajjangarh Sanctuary occasionally since 1986, but had never seen this species till these sightings. Since the last two years, some farmers of Gorella village, at the southern border of the Sanctuary, have started growing sugarcane. The cultivation of sugarcane could have attracted the birds to the area.

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11. SIGHTING OF ALBINO COMMON SAND BOA *GONGYLOPHIS CONICUS* FROM NORTHERN WESTERN GHATS, MAHARASHTRA, INDIA

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During a faunistic survey of the Northern Western Ghats in Maharashtra, the first author sighted an albino Common Sand Boa *Gongylophis conicus* (Schneider, 1801) at Laling Ghat Forest (20° 47' 36" N; 74° 44' 14" E; 380 m above msl) in Dhule district on October 07, 2011. The boa was pale pinkish to whitish with obscure faint patches on its body. It had red eyes and a reddish tongue. The snake was resting under dense vegetation on moist sandy soil near the bank of a reservoir below the Laling Waterfall. The sand boa had a total body length of about 70 cm. It was photographed (Fig. 1) and released where it was found. It was sighted again in December 2011, in the same locality and habitat. The sighting of a full grown albino is significant as most albinos are easily noticed and fall prey to predators.

There are very few reports on albinism in reptiles in general and snakes in particular from India (D'Abreu 1918, Lahiri 1955, Kumar 1988). There are also no published reports of total albinism both in the family Boidae, and in the Common Sand Boa. Whitaker (1971) has recorded a specimen

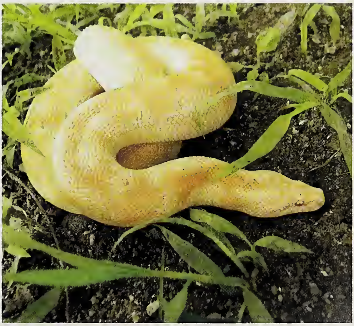

Fig. 1: The albino Common Sand Boa was released after being photographed

of Russell's Sand Boa *Eryx conicus* (now *Gongylophis conicus*) collected near Madras (now Chennai), which was uniform pale cream in colour, the underside being slightly lighter and the eyes were black, which could be a case of partial albinism. Our sighting is perhaps the first record of total albinism in this species and for Boidae from India.

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12. REPORT OF AN ALBINO BEAKED WORM-SNAKE *GRYPTOTYPHLOPS ACUTUS* (DUMÉRIL AND BIBRON, 1844)

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The Beaked Worm-snake *Gryptotyphlops acutus* is a non-venomous snake of the family Typhlopidae. It is endemic to India and distributed almost all over the Indian peninsula south of the Indo-Gangetic plain. *G. acutus* is 'glossy brown above, distinctly paler below' (Whitaker and Captain 2004).

In this communication, we report a rare instance of an albino Beaked Worm-snake from Maharashtra, India. The first author spotted the snake at around 11:30 hrs on September 18, 2011, at Sutarwadi hamlet of Gimhavane village near Dapoli outside his house. The house is surrounded by rice fields, trees on bunds, and sparse habitation. The snake was brought to the College of Forestry, Dapoli. It was observed, photographed (Fig. 1) and released back from where it was collected.

It was completely white. The identity of the specimen as *G. acutus* was ascertained based on the enlarged shield-like rostral scale (Fig. 2). No scalation data was recorded. The total length of the specimen was 44 cm. Its scales were white, with those towards the head having a pinkish tinge. Eyespots could not be discerned.

This is, perhaps, the first report of albinism in *G. acutus*. This specimen was an adult with its length reaching three fourths of its recorded maximum length (Whitaker and Captain 2004). This is an instance of an albino snake surviving to adulthood, contrary to what is reported (see Krecsak 2008), and suggests that albino snakes can survive to adulthood even in the wild.

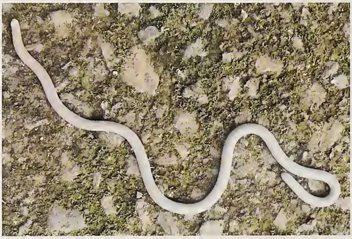

Fig. 1: Albino *Gryptotyphlops acutus* from Dapoli, Maharashtra

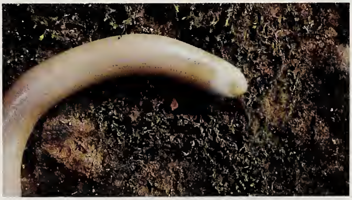

Fig. 2: View of head showing enlarged rostral scale of *Gryptotyphlops acutus*

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13. FIRST REPORT OF *KALOULA TAPROBANICA* PARKER, 1934 FROM RAJASTHAN, ALONG WITH UPDATED LIST OF ANURANS AND THEIR REVISED DISTRIBUTION IN RAJASTHAN, INDIA

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Kaloula taprobanica Parker, 1934, is commonly known as Indian Painted Frog (Daniels 2005) or Sri Lankan Bullfrog (Das and Dutta 1998). In India, the distribution of the Indian Painted Frog is all over the eastern states (Boulenger 1890; Dutta 1997; Chanda 2002; Daniel 2002; Daniels 2005) along with discrete reporting from Gujarat

Table 1: Updated list of anuran species of Rajasthan and their distribution

Sr. No.	Scientific Name	Common Name	Distribution (districts)
	Family Dicroglossidae		
1	*Euphlyctis cyanophlyctis*	Indian Skipper Frog	Entire State
2	*Euphlyctis hexadactylus*	Indian Pond Frog	Jaipur
3	*Hoplobatrachus tigerinus*	Indian Bull Frog	Ajmer, Bhilwara, Nagaur, Tonk, Bharatpur, Dholpur, Karauli, Sawai Madhopur, Bikaner, Jaipur, Alwar, Sikar, Dausa, Jalore, Jodhpur, Pali, Sirohi, Baran, Bundi, Jhalawar, Kota, Banswara, Chittorgarh, Pratapgarh, Dungarpur, Udaipur, Rajsamand
4	*Fejervarya limnocharis*	Cricket Frog	Ajmer, Bharatpur, Karauli, Jaipur, Alwar, Jalore, Pali, Sirohi, Bundi, Jhalawar, Kota, Banswara, Chittorgarh, Pratapgarh, Dungarpur, Udaipur, Rajsamand
5	*Sphaerotheca breviceps*	Short-headed Burrowing Frog	Bharatpur, Jaipur, Pali, Sirohi, Chittorgarh, Pratapgarh, Udaipur
6	*Sphaerotheca rolandae*	Roland's Burrowing Frog	Ajmer
	Family Bufonidae		
7	*Duttaphrynus melanostictus*	Common Asian Toad	Bharatpur, Dholpur, Sirohi, Jaipur, Chittorgarh, Pratapgarh, Udaipur
8	*Duttaphrynus stomaticus*	Marbled Toad	Jaipur, Ajmer, Bikaner, Ganganagar, Nagore, Jhunjhunu, Sirohi, Chittorgarh, Pratapgarh, Udaipur
9	*Duttaphrynus viridis*	Green Toad	Jaipur
	Family Microhylidae		
10	*Microhyla ornata*	Ornate Narrow-mouthed Frog	Bharatpur, Jaipur, Jalore, Pali, Sirohi, Banswara, Chittorgarh, Pratapgarh, Dungarpur, Udaipur, Rajsamand
11	*Uperodon systoma*	Marbled Balloon Frog	Bharatpur, Jaipur, Jalore, Sirohi, Udaipur
12*	*Kaloula taprobanica*	Indian Painted Frog	Chittorgarh, Pratapgarh
	Family Rhacophoridae		
13	*Polypedates maculatus*	Indian Tree Frog	Chittorgarh, Udaipur

* First record from Rajasthan by the authors.

(Naik *et al.* 1993; Vyas and Patel 1994) and Madhya Pradesh (Chandra and Gajbe 2005; Dutta 1997), and southern India (Dutta *et al.* 2009). Outside India, it has been reported from Bangladesh and Sri Lanka (Inger *et al.* 2004).

We recorded the species in 2009 from Chittorgarh district, Rajasthan, India, and this is the first confirmed record (voucher registration no. Micro-KT-23° 58' 4.31" N/74° 01' 26.91" E-HM040961, Herpetology Unit Department of Zoology, MDS University, Ajmer) of the species from this state. The nearest report of the species from this site is from Gujarat and Madhya Pradesh, India.

With the addition of this species, the number of anurans of Rajasthan comes to 13 (Table 1) from the earlier reported 12 (Sharma and Mehra 2007).

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14. FIRST RECORD OF *KALOULA ASSAMENSIS* DAS *ET AL.* (2004) (MICROHYLIDAE) FROM BIHAR STATE, INDIA, WITH NOTES ON ITS DISTRIBUTION

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The Assam Painted Frog *Kaloula assamensis* Das, Sengupta, Ahmed, and Dutta (2004), a data-deficient species, was described based on specimens collected from four localities in eastern Assam, Majbat (26° 45' N; 92° 20' E), Sirajuli (26° 42' N; 92° 12' E), Nameri Wildlife Sanctuary (26° 56' N; 92° 52' E) in Sonitpur district, and Orang National Park (26° 30' N; 92° 15' E) in Darrang district, and one locality in Arunachal Pradesh, Pakhui Wildlife Sanctuary (26° 55' N; 92° 51' E) in Kameng district. The species was subsequently reported from Bongaigaon (26° 28' N; 90° 31' E) in western Assam (Talukdar *et al.* 2007), thereby extending the range by 170 km to the west. Thereafter, the species was reported from Chilapata Reserve Forest (26° 32' N; 89° 25' E) in Jalpaiguri district of West Bengal (Paul *et al.* 2007) extending the range by another 140 km to the west. Sengupta *et al.* (2009) speculated that the global distribution of the species was restricted to the north bank of the Brahmaputra river between the longitudes 92° and 89° E and may occur in low elevation areas of the Indo-Bhutan border.

A specimen of *Kaloula assamensis* bearing registration number ZSIC A 8878, was collected by Sukumar Ray on November 05, 1996, from the hollow trunk of a tree, *c.* 1 m above ground in a grassland at Manguraha (27° 28' N; 84° 12' E), Valmiki Tiger Reserve, West Champaran district, Bihar. It was wrongly reported as *Kaloula pulchra taprobanica* (Ray 1998). This specimen can be identified as *Kaloula assamensis* from its small adult size (SVL 30.7 mm), presence of a bright yellow vertebral stripe commencing from tip of snout and terminating near the vent and broad dark brown lateral stripes on either side from the post ocular to the inguinal region. It can be distinguished from *Kaloula taprobanica* which is larger (SVL 35–55 mm), by the presence of several black-edged reddish-brown irregular blotches on the dorsum, and absence of the bright yellow vertebral stripe. It can also be distinguished from *Kaloula pulchra* which is even larger (SVL 45–85 mm) by the yellow head, with two broad dorso-lateral elongated yellow patches on either side, and absence of yellow vertebral stripe. This collection from Valmiki Tiger Reserve extends the range of the species by about 600 km further to the west, and constitutes the first record from Bihar. It now appears that the species is distributed all along the Terai belt, from Arunachal Pradesh to Bihar (92° to 84° E), along both the Indo-Bhutan and Indo-Nepal borders.

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15. ADDITION OF THREE ANGELFISH (FAMILY: POMACANTHIDAE) TO THE ICHTHYOFAUNA OF WEST BENGAL, INDIA

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The ichthyofauna of West Bengal coastal waters has been reported by several workers (Chatterjee *et al.* 2000; Das *et al.* 2007; Goswami 1992; Khan 2003; Manna and Goswami 1985; Talwar *et al.* 1994). There is no report of family Pomacanthidae (angelfish) in these publications. However, during a survey around Digha coast we collected three species of Pomacanthidae, namely *Pomacanthus imperator* (Bloch, 1787), *P. annularis* (Bloch, 1787), and *P. semicirculatus* (Cuvier, 1831), and in this paper, we give the morphometrics and other details of the collected specimens.

Pomacanthidae is characterised by a sharp spine located at the lower front area of the gill cover, or preopercle region. The presence of this spine on each side distinguishes and separates them from their close butterflyfish (Family: Pomacanthidae) relatives, which do not have the spine. Family Pomacanthidae contain 9 genera and 74 species mainly associated with coral reefs around the world (Chen and Tzeng 2009; Froese and Pauly 2011). They do generally well in the aquarium (Rao 2003), are very good food fish and of high economic value (Barman *et al.* 2004). All the members of angelfishes are strictly marine, inhabit shallow reefs, but some live in deep water. Of these, *Pomacanthus* species, which we recorded during the survey, are reported to be cleaners, removing ectoparasites from other fish. Juveniles are extremely different in colour pattern from adults (Allen *et al.* 1998; Randall 1996), and have a very high demand in the marine aquarium trade (Rao 2003).

All three specimens of *Pomacanthus* collected were from Digha Mohona (21° 37.84' N; 87° 32.83' E). After taking photographs, the specimens were preserved in

Table 1: Morphometric characteristics of the three species of angel fish (*Pomacanthus* spp. recorded during the survey)

Character	*P. imperator*	*P. annularis*	*P. semicirculatus*
% of Standard Length			
Total Length	85.06	83.09	85.38
Body Depth	61.22	71.18	64.38
Head Length	26.12	22.71	28.08
Caudal Fin Length	17.55	20.33	17.12
Predorsal Length	36.73	37.28	39.72
Preanal Length	71.02	64.40	67.80
Pectoral Fin Length	24.08	23.05	26.02
Ventral Fin Length	29.18	29.15	33.56
Caudal Peduncle Length	5.10	6.44	12.32
Caudal Peduncle Depth	12.6	14.91	15.06
% of Head Length			
Eye Diametre	21.09	22.38	23.17
Inter-orbital	37.5	43.28	34.14
Snout	46.87	37.31	26.58
Pre-opercular	41.40	40.29	29.26

10% formaldehyde and kept in the museum of Marine Aquarium and Regional Centre of Zoological Survey of India, Digha. Three specimens, one from each species, were collected and identified as the following: *Pomacanthus annularis* – Reg. no: F1965; Date of collection: 10.x.2011, Total length: 355 mm. *Pomacanthus imperator* – Reg. no: F1972; Date of collection: 24.x.2011, Total length: 288 mm. *Pomacanthus semicirculatus* – Reg. no: F2277; Date of collection: 16.i.2012, Total length: 171 mm.

Details of morphometric characters of all the three species are presented in Table 1 and also described below:

Bluering Angelfish *Pomacanthus annularis* (Bloch, 1787)

Meristic formula: D: XIII, 21; A: III, 20; P: 19; V: I, 5; LI: 70; GR: 20.

Diagnostic Character: Body compressed and disc like; rostro-dorsal profile straight to nape; snout bluntly pointed. Body and head covered with small, rounded, ctenoid scales. Mouth small with numerous long teeth of equal size. Very small denticles present in the posterior and lower edges of pre-operculum; a strong spine present at the angle of pre-operculum. Inter-orbital space is wider than eye diameter. Lateral line arched and complete. Gill rakers 6 on upper limb and 14 on lower limb of the first arch. Anterior nostril oval, twice longer than round posterior. Soft dorsal pointed, soft anal and caudal fin rounded.

Colour: Body greyish-brown, with conspicuous 7 brilliant blue curved lines radiating from pectoral fin to soft dorsal fin, the last one crossing the caudal peduncle. Two blue horizontal lines present on opercle, the upper one crossing the eye from above the snout to the edge of the operculum and lower one below the eye. A blue ring present slightly above the edge of the operculum near lateral line. Caudal fin white with yellow margin and pectoral fins yellowish; ventral fins greyish.

Habitat: Found around reef slopes, at least 30 m depth (Lieske and Myers 1994); feeds on sponges and tunicates (Pyle 2001). Adult often found in pairs inside caves (Kuiter and Tonozuka 2001).

Distribution: The species is distributed along Indo-West Pacific: east coast of Africa, throughout Indonesia and New Guinea to New Caledonia, north to southern Japan (Froese and Pauly 2011). From Indian waters, this species was reported from Andaman and Nicobar Islands (Rao *et al.* 2000; Kamala Devi and Rao 2003; Rao 2003, 2010), Andhra Pradesh (Barman *et al.* 2004), Gulf of Mannar, Tamil Nadu (Talwar and Kacker 1984) and Gujarat (Deshmukhe *et al.* 2000).

Emperor Angelfish *Pomacanthus imperator* (Bloch, 1787)

Meristic Formula:D:XIV, 20; A: III, 20; P:19; V: I, 5; LI: 78; GR: 19.

Diagnostic character: Body oval shaped, deeply compressed; snout blunt; rostro-dorsal profile slightly convex. Body and head covered with small ctenoid scales. Head small, slightly concave in its dorsal profile. Small mouth with numerous teeth forming a brush-like surface. Anterior teeth in both jaws are the longest, no teeth in vomer and palatine. Pre-operculum finely serrated, the angular pre-opercular spine strong and longer than eye, inter-orbital space wider than eye diameter. Posterior nostril oval and slightly larger than rounded anterior nostril. Gill rakers short with 6 on upper limb and 13 on lower limb of first arch. Posterior edge of dorsal, anal and caudal fins are rounded.

Colour: Body and the adjoining dorsal and anal fins with diagonal alternating stripes of purplish-blue and narrower yellow. Snout and cheek bluish-white; eye enclosed in a black vertical bar with blue edge; greenish-grey with light blue margin extending from forehead to base of pre-opercular spine. Caudal fin yellow, a broad black bar present at the level of pectoral; pectoral and pelvic fins yellowish; soft dorsal and anal fin with numerous yellow bands.

Habitat: Emperor angelfish inhabit outer coral reefs near caves and coral ledges at depths of 5–60 m (Golani *et al.* 2010; Rao 2003). Benthopelagic (Mundy 2005). It generally feeds on sponges, tunicates, and other encrusting organisms (Anderson and Hafiz 1987). Solitary or in pairs, the male shows territoriality against conspecific males (Golani *et al.* 2010).

Distribution:The species is distributed along the Indo-Pacific, from the Red Sea and eastern Africa to Japan, Tuamoto islands, Hawaii (Golani *et al.* 2010; Randall 2007) and the Ogasawara Islands, south to the Great Barrier Reef, New Caledonia, and the Austral Islands (Fricke 1999). In Indian waters, reported from Andaman and Nicobar Islands (Kamala Devi and Rao 2003; Rao *et al.* 2000; Rao 2003, 2010), Andhra Pradesh (Barman *et al.* 2004), Lakshadweep (Murty 2002), Tamil Nadu: Cuddalore coast (Lakshmi and Sundaramanickam 2011) and Gulf of Mannar (Talwar and Kacker 1984).

Semicircular Angelfish *Pomacanthus semicirculatus* (Cuvier, 1831)

Meristic Formula: D: XIII, 21; A: III, 19; P: 20; V: I, 5; Ll: 67; GR: 18.

Diagnostic character: Body moderately compressed and deep. Rostro-dorsal profile ascending in a more or less straight line to nape, slightly concave at snout. Head small, mouth also small with numerous brush-like teeth in both jaws. Scales on body unequal and without auxiliaries. Anterior nostril is oval and larger than the rounded posterior. Hind border of pre-opercle minutely serrated; angular pre-opercular spine slightly larger than eye. Spinous dorsal fin slightly longer than soft rays; soft anal and soft dorsal fins are acute and prolonged like filaments. Lateral line arched and ends in caudal. Gill rakers short with 5 on upper limb and 13 of lower limb of first arch. Third anal spine longest; pectoral fins slightly shorter than head length; ventral fins acute and caudal fin rounded.

Colour: Mouth pale yellow. Anterior and posterior part of body brownish, yellowish-grey in the middle. Dorsal, anal, caudal fin margins, and pre-opercular edge are blue with yellowish tips; pectoral fins yellowish. Numerous blue spots on body.

Habitat: This species generally prefers protected coral reefs with developed coral to a depth of 40 m. Generally solitary or in pairs. Feeds mainly on sponges, algae, and tunicates (Allen *et al.* 1998; Randall 1996).

Distribution: The species is distributed along the Indo-West Pacific from the Red Sea and East Africa to Palau and Fiji, southern Japan to New South Wales, Lord Howe Island and New Caledonia (Allen *et al.* 1998; Randall 1996). In Indian coastal waters, it was reported from Andaman and Nicobar Is (Rao 2003); Chennai coast (Barman *et al.* 2011).

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16. RECORD OF BANDED LEOPARD BLOWFISH *AROTHRON LEOPARDUS* (DAY, 1878) (TETRAODONTIFORMES: TETRAODONTIDAE) FROM MUVATTUPUZHA RIVER, KERALA, INDIA

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Introduction

Puffer fishes are circumglobal in tropical and temperate waters (Talwar and Jhingran 1991). Most species are marine, but several enter estuaries and some live only in freshwater. *Carinotetraodon travancoricus*, the only freshwater pufferfish endemic to Kerala, was described first from Pampa river, Kerala (Hora and Nair 1941). It was later reported from the Nilgiri Biosphere Reserve in the Kerala part of Western Ghats (Easa and Shaji 1997), Mavincar in South Canara, Karnataka (Remadevi *et al.* 2000), and Muvattupuzha, Periyar, and Chalakkudy rivers of Kerala (Jameela Beevi and Ramachandran 2009). *Chelonodon patoca* belonging to the family Tetraodontidae was reported from Aghnashini river in Kritikada, Karnataka, and from Payaswani river at Eranchipuzha in Kasargod district, Kerala (Arunachalam *et al.* 1999, 2009). Recent studies of Zeena and Jameela Beevi (in press), reported the presence of *Tetraodon fluviatilis*, the Green Pufferfish from Muvattupuzha river, Kerala.

Banded Leopard Blowfish *Arothron leopardus* (Family Tetraodontidae) were recorded from the Muvattupuzha river while conducting ichthyofaunal studies from August 2010 to August 2011. According to Day (1878), *A. leopardus* occurs in the seas of India. It has also been reported from seas of India (Day 1878), Pulicat Lake (Raj *et al.* 2002), Chennai coast (Ramesh *et al.* 2008), southwest coast of India (Biju Kumar and Deepthi 2009) and Ayiramthengu, Kollam (Balasubramanian and Ajmal 2004). In addition to the report of this species from Ayiramthengu (Balasubramanian and Ajmal 2004), the occurrence of *A. leopardus* in Muvattupuzha river is an additional locality for Kerala and extends its range to the freshwater systems of Kerala.

Table 1: Biometrics of *Arothron leopardus* n=20 (in mm)

Morphometrics	Min.	Max.	Mean	S.D.
Standard length				
%SL	70	143		
Body depth	32.2	41.2	36.6	2.8
Head length	33.6	38.1	35.8	1.9
Predorsal length	68.5	77.3	72.9	2.8
Dorsal fin length	17.2	20.6	19.1	1.1
Pectoral fin length	12.6	16.5	14.7	1.3
Anal fin length	15.8	18.8	17.4	1.1
Caudal fin length	24.5	29	26.9	1.8
% HL				
Snout length	40	46.3	43.6	2.2
Eye diametre	20.8	36	26.4	5.0
Interorbital distance	44	52.1	49.0	3.0
Meristic counts				
Dorsal fin rays	11			
Pectoral fin rays	18			
Anal fin rays	9			
Caudal fin rays	11			

Twenty specimens of the species were collected from two sites, Palamkadavu and Thattaveli, in Muvattupuzha river (9° 47' 00" N; 76° 21' 00" E), in Kottayam district of Kerala by using hook and line, and drag net. The specimens were fixed in 10% formalin and preserved in alcohol. The biometrics were measured using a metre scale and divider (Table 1) as per Jayaram (1999), and identification was based on Day (1878) and Nelson (2006). The morphometric characters of the specimens are discussed below.

The body is elongated and arched dorsally: ventrally flat. Depth of the body is 32.2–41.2% SL (Standard Length). Head is broad and its length is 33.6–38.1% SL. Mouth is terminal and jaws with a median suture. Gill openings are narrow and ending before the middle of pectoral fin base. Eyes are large, dorsolateral in position and situated slightly anterior to the middle of the head length. Interorbital distance is broad. Eye diameter (ED) is 20.8–36% HL (Head Length). Nasal organ is in the form of two elongated raised flaps and very close to the eyes. Snout length (Sn L) is 40–46.3% HL. Dermal spines are concealed in the skin.

Dorsal fin is rounded and is situated in the last third of the distance between the front edge of the eyes and caudal peduncle. Its length is 17.2–20.6% SL. Pectoral fin is fan-like and placed in the middle of the body. Its length is 12.6–16.5% SL. Anal fin is round, 15.8–18.8% SL and placed opposite to the dorsal fin. Caudal fin is truncate and its length 24.5–29% SL.

There are three narrow cross bands across the body. The one over the head is V-shaped with a light interorbital band posterior to it. The second is in the space between the pectoral fin, on either side. The posterior band is placed slightly ahead of the dorsal fin origin. On the dorsal side, two lines are prominent, which start from the snout, lie under the eyes on both sides and curve upwards above the pectoral fin, extending backwards along dorsal side. In the region below the dorsal fin origin, it is again curved downwards toward the anal fin and ends at the caudal fin base. These lines are interconnected at the snout region. Lines are not continuous and prominent on the ventral side. Inconspicuous lines are present around the eyes, which are connected by an interlink at the nape.

The body is olive superiorly and it extends to two thirds of the distance down the sides. Ventrally, it is white. Numerous fluorescent yellow spots are distributed in the body from the snout to the caudal fin except the region below the level of pectoral fin. Spots are varied in size. 4–5 vertical rows of spots are present on the caudal fin.

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17. *ADENIUM OBESUM* (FORSK.) (APOCYNACEAE) – A NEW LARVAL HOST PLANT OF THE COMMON INDIAN CROW *EUPLOEA CORE* (CRAMER) (LEPIDOPTERA: NYMPHALIDAE)

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The Common Indian Crow *Euploea core* (Cramer), belonging to the sub-family Danainae and family Nymphalidae, is the commonest among the tigers and crows (Kunte 2000) and is widely distributed in India below 2,438 m (Wynter-Blyth 1957). It is a polyphagous insect known to lay it eggs on several species of plants of different families: Apocynaceae (dogbanes and oleanders), Asclepiadaceae (milkweeds), Moraceae (figs), Rubiaceae, Sapotaceae, and Ulmaceae (nettles) (Kehimkar 2008; Kunte 2000; Palot and Radhakrishnan 2001; Palot *et al.* 2005; Robinson *et al.* 2001; Wynter-Blyth 1957).

On the morning of September 27, 2010, a Common Indian Crow was observed laying eggs on the leaves and flowers of *Adenium obesum* (Forssk.) Roem. & Schult. (family: Apocynaceae) near Contai (21° 46' 40" N; 87° 44' 50" E; 6 m above msl), East Midnapore district, West Bengal, India. After close observation, a few larvae of different instars were also seen feeding on the leaves of the plant. *Adenium obesum*, commonly known as Mock Azalea or Desert Rose, is native to East Africa, Arabia and Socotra. It is also found in the wild in West Africa, especially in Senegal and Nigeria (Bose *et al.* 1991). This succulent shrub has wide adaptability and can grow well from very dry tropics to hot and humid climate. This species is now a naturalised garden plant in India. Our observations on the Common Indian Crow feeding on the exotic *Adenium obesum* is a new addition to the existing list of known larval food plants of the species.

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18. A REPORT ON WEED-ASSOCIATED MITES OF SOUTH BENGAL AND THEIR POSSIBLE ROLE IN WEED CONTROL

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Introduction

Weeds are serious pests in agro-ecosystems because they extract and deprive soil nutrients meant for agricultural crops, and thus, adversely affect the growth and yield of crop plants. Hence, weed control is becoming an important agricultural practice through chemical control, and to a certain extent, biological control. Among the biocontrol agents, insects have been found to be quite promising in suppressing weeds. Information on mites in weed control is scarce, with the exception of some work (Kumar *et al.* 1979; Dagar and Singh 1979; Das and Roychaudhuri 1979; Jagannath and Visalakshy 1989). In view of this, a preliminary attempt was

Table 1: Details of mite species collected from weeds of South Bengal

Order and Family	Species	Host Plant	Locality (District)	Date of Collection	Remarks
Order Prostigmata					
Family Tetranychidae	*Eutetranychus maximae* Nasar and Ghai	*Lantana camara* L.	Narendrapur (South 24 Parganas)	1.iv.2011	Infests the upper surface of leaf, without showing any noticeable damage.
	Tetranychus urticae Koch	*Parthenium hysterophorus* L.	Narendrapur (South 24 Parganas)	1.iv.2011, 15.iv.2011	Occurs on the lower surface of the leaves, the colony is covered with thin webs. The feeding induced yellowing of leaves initially, followed by browning and drying of leaves.
	Tetranychus neocaledonicus Andre	*Amaranthus viridis* L.	Dakshin Barasat (South 24 Parganas)	2.v.2011	Causes chlorosis of leaves.
		Urena lobata L.	Dakshin Barasat (South 24 Parganas)	2.v.2011	Causes chlorosis of leaves.
		Acalypha indica L.	Narendrapur (South 24 Parganas)	16.v.2011	A stray occurrence of this species was noticed on this host causing chlorosis of leaves.
	Tetranychus ludeni Zacher	*Abutilon indicum* (L.) Sweit.	Narendrapur (South 24 Parganas)	16.v.2011	Heavy infestation, especially at the base of petiole, causing discoloration, yellowing and subsequent drying.
	Petrobia harti (Ewing)	*Oxalis corniculata* L.	Kalyani Agriculture farm (Nadia)	1.vi.2011	Severe infestation by this mite on both surfaces of leaves, leading to yellowing and browning of leaves.
	Schizotetranychus andropogoni (Hirst)	*Cyperus rotundus* L.	Narendrapur (South 24 Parganas)	15.vi.2011	Whitish patches, arranged longitudinally on either side of midrib, leading to gradual drying up of leaves.
Family Tarsonemidae	*Polyphagotarsonemus latus* (Banks)	*Physalis minima* L.	Mukundapur (South 24 Parganas)	1.vii.2011	Infests the lower surface of young leaves, causing crinkling of leaves.
Family Tenuipalpidae	*Brevipalpus deleoni* (Banks)	*Solanum nigrum* L.	Narendrapur (South 24 Parganas)	5.vii.2011	Infested leaves developed brownish patches and dried later.
	Tenuipalpus quadrisetosus Lawrence	*Chenopodium album* L.	Kalikapur (South 24 Parganas)	20.vii.2011	Recorded on host, doing no damage.
	Swarnanychus sp.	*Leea* sp.	Narendrapur (South 24 Parganas)	30.v.2011	Induced no visible symptoms of damage; represented the second species of this genus known so far.

Table 1: Details of mite species collected from weeds of South Bengal (*contd.*)

Order and Family	Species	Host Plant	Locality (District)	Date of Collection	Remarks
Family Eriophyidae	*Aceria dactylonae* Mohanasundaram	*Cynodon dactylon* (L.) Pers.	Kalikapur (South 24 Parganas)	30.vii.2011	Seen as vagrant on lower surface of leaf.
	Aceria justicae Channabasavanna	*Achyranthes aspera* L.	Kalyani Agriculture farm (Nadia)	31.vii.2011	A leaf vagrant, and no damage noticed.
Order Mesostigmata					
Family Phytoseiidae	*Amblyseius largoensis* (Muma)	*Croton sparciflorus* (Morung)	Narendrapur (South 24 Parganas)	30.iv.2011	A predatory mite; though common on this plant, no feeding on any prey noticed.
	Euseius ovalis (Evans)	*Urena lobata* L.	Narendrapur (South 24 Parganas)	28.iv.2011	An efficient predator. Abundant feeds on all stages of *Tetranychus neocaledonicus*.
	Euseius sp. nov.	*Eleusine indica* Gaertn.	Mukundapur (South 24 Parganas)	28.v.2011	Appears to be a new species.
	Anthoseius bakeri (Garman)	*Premna orientalis* L.	Narendrapur (South 24 Parganas)	1.viii.2011	Stray occurrence on this host.
Family Ameroseiidae	*Kleemania plumigera* Oudemans	*Lantana camara* L.	Kalikapur (South 24 Parganas)	5.viii.2011	Casual occurrence in inflorescence.
Order Astigmata					
Family Acaridae	*Acarus gracilis* Hughes	*Hygrophila schulli* (Buch.-Ham.) M.R. et. S.M. Almeida	Narendrapur (South 24 Parganas)	11.viii.2011	A fungivorous mite, showing only accidental occurrence.

made to explore mites occurring on weeds in selected agro-ecosystems in South Bengal and to observe their role, if any, in weed control.

Material and methods

The mites were collected from agricultural fields in the districts of South and North 24 Parganas and Nadia of West Bengal during April to August 2011. The weeds were examined with a 20x hand lens and the mites were collected from the leaves with the help of a fine, moistened brush. Preservation was done in 70% alcohol and the mites were temporarily mounted in lactic acid for examination under a microscope. Permanent slide preparations were made in Hoyer's medium.

Results and Discussion

The occurrence of 18 species under 14 genera and 6 families, belonging to 3 orders were recorded in the 20 species of weeds examined (Table 1). Of these, 12 species under 4 families were phytophagous and the rest belonged to the predatory group. Among the phytophagous species, 4 species, namely *Tetranychus urticae*, *T. neocaledonicus*, *Petrobia harti*, and *Polyphagotarsonemus latus* were found severely infesting weeds (Table 1), causing loss of vitality and producing damage symptoms. Therefore, these four species may be of some importance in weed control. The population of other mites was comparatively low to exert any potential effect in reducing weed population. Other than the phytophagous mites, predatory mites of the order Mesostigmata and Astigmata were also recorded occasionally on some weed species (Table 1); the economic significance of these species is unknown.

Mite infestation on weeds has been reported from various parts of India by earlier workers. Das and Roychaudhuri (1979) reported the occurrence of *Polyphagotarsonemus latus* on *Physalis minima*. Mukherjee *et al.* (1987), Jagannath and Visalakshy (1989), Julien and White (1997), Julien and Griffiths (1998), Julien (2001), and Haq and Sumangala (2003) reported several mites on aquatic weeds. Most recently, Gupta (2011) reported about a dozen mite species occurring on weeds in India. The present study, though a preliminary work, forms the first report on mites associated with weeds in South Bengal and points to the scope and need for conducting more intensive studies on weed associated mites.

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19. A PRELIMINARY REPORT ON INSECT-ASSOCIATED MITES OF SOUTH BENGAL, INDIA

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Introduction

Members of various orders of insects are often found infested by mites of different groups and the association between them may be of temporary nature for passive transport or may be commensalistic, parasitic, or predatory (Hunter and Rossario 1988). The parasitic/predatory behaviour of mites may be exploited in biological control of insect pests, and hence, insect-associated mites have received importance and studies have been initiated to explore their association with insects, especially those of agricultural importance. Most of the published works available from India are from southern India. In this paper, we discuss the insect associated mites of West Bengal, based on a preliminary study carried out by us from South 24 Parganas district from February to August 2011.

Material and Methods

Insects were collected from different agricultural and horticultural fields of South 24 Parganas district of West Bengal with the help of a collecting net and light trap. The insect collected were thoroughly examined under a stereo-binocular microscope to record the mites associated with them. The insect groups collected and examined for mites were members of the orders Lepidoptera, Hemiptera, Diptera, Coleoptera, Hymenoptera, and Odonata. Different body parts of the insect, such as the underside of proboscis and elytra, wing base, legs, area between head and thorax, and antennae were examined for collection of mites. The specimens were temporarily mounted in lactic acid for microscopic observation. Permanent slides were prepared in Hoyer's medium. The slide mounted specimens were examined and identified under a microscope, following appropriate identification keys and literature. The identification of host insects was made mostly by experts of the Zoological Survey of India, Kolkata.

Results and Discussion

Ten species of mites under 10 genera, 9 families and 3 orders were recorded from the six orders of insects examined (Table 1). The mesostigmatid mites collected were *Alliphis* sp., *Amblyseius largoensis* (Muma), *Hemipteroseius indicus* Krantz and Khot, *Macrocheles muscaedomesticae* (Scopoli),

Table 1: Details of species collected from insects of South Bengal

S. No.	Order / Family	Species	Host	Location	Date of Collection	Body parts of insect where recorded
1	Order Mesostigmata Family Eviphidae	*Alliphis* sp.	Lepidoptera (*Junonia* sp.)	Baruipur	27.ii.2011	All under proboscis, below wing base, leg
		Alliphis sp.	Lepidoptera (*Papilio demoleus* Linn.)	Narendrapur	15.v.2011	
		Alliphis sp.	Lepidoptera (*Agrotis* sp.)	Science City Area	18.v.2011	
2	Family Phytoseiidae	*Amblyseius largoensis* (Muma)	Hemiptera *Leptocorisa acuta* (Thunb.)	Chinsura	12.ii.2011	Between head and thorax, below elytra
3	Family Otopheidomenidae	*Hemipteroseius indicus* (Krantz & Khot)	Hemiptera *Dysdercus koenigii* Fabr.	Narendrapur Kalikapur	26.iii.2011 04.vi.2011	Ventrally, on thorax

Table 1: Details of species collected from insects of South Bengal (*contd.*)

S. No.	Order / Family	Species	Host	Location	Date of Collection	Body parts of insect where recorded
4	Family Macrochelidae	*Macrocheles muscaedomesticae* (Scopoli)	Diptera *Musca domestica* Linn.	Baruipur Baruipur	24.iv.2011 12.vi.2011	Below antennae, wing base
5	Family Ascidae	*Blattisocius keegani* (Fox)	Lepidoptera (*Danais* sp.)	Kalikapur	04.viii.2011	Under proboscis, below wing base, leg
6	Family Eviphidae	*Eviphis* sp.	Coleoptera (*Henosepilachna vigintioctopunctata*) Fabr.	Science City area	04.viii.2011	Below elytra
7	Order Astigmata Family Acaridae	*Rhizoglyphus echinopus* (F and R)	Coleoptera (*Aspidomorpha* sp.)	Baruipur Narendrapur	20.ii.2011 12.vi.2011	On ventral surface, area between head and thorax
8	Family Anoetidae	*Sennertia* sp.	Hymenoptera *Xylocopa* sp.	Narendrapur Baruipur	13.iii.2011 18.iii.2011	On ventral surface
9	Family Acaridae *berlesei* (Michael)	*Caloglyphus*	Coleoptera *Coccinella* sp.	Narendrapur	10.iv.2011	On ventral surface, area between head and thorax
10	Order Prostigmata Family Arrenuridae	*Arrenurus* sp.	Odonata	Science City area	04.viii.2011	Below antennae, area between head and thorax

Blattisocius keegani Fox and *Eviphis* sp. Of these, *Alliphis* sp. and *Blattisocius keegani* collected from Lepidoptera, *Hemipteroseius indicus* from red cotton bug, and *Macrocheles muscaedomisticae* from the housefly, were the most common species. Similar findings were reported by Ramaraju (2009) from Tamil Nadu. However, the *Alliphis* sp. collected during this study appears to be different from *Alliphis trichiensis* Ramaraju and Mohanasundaram, and also from all the other known species. This clearly indicates that the present species of *Alliphis* may probably represent a new taxon.The record of *A. largoensis* in our study appears to be a case of accidental occurrence, as it is a leaf inhabiting predatory mite. The association of other mesostigmatid mites was phoretic.

The present report includes three species of astigmatid mites of which *Sennertia* sp. appears to be a new species. The other two species of this order are truly phoretic Ramaraju and Mohanasundaram (1998, 1999) reported 7 species of this order from Tamil Nadu, associated with insects.

Ramaraju (2009) reported 17 species under 17 genera; this study reports 6 species from 10 genera. Only one species of Prostigmata, i.e. *Arrenurus* sp., was collected in this study, while Ramaraju (2009) reported 9 species of Prostigmata under 9 genera.

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20. *BEGONIA HIRTELLA* LINK – AN ADDITION TO THE FLORA OF KERALA, INDIA

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Introduction

During our visit to the Tropical Botanical Garden and Research Institute (TBGRI), Phallode, Kerala, a species of *Begonia* was seen growing on the compound wall of a house, which was later identified as *Begonia hirtella* Link, native to Tropical America and commonly known as Fringed Begonia. The species had been reported as a new record for Indian flora by Bachulkar and Yadav (2000) from Belgaum district, Karnataka.

The identity of the specimens, which were deposited in Shivaji University (MMA-4) was confirmed by comparing with images of a colour plate (Edwards's Botanical Register, t. 1252), images of Type in Botanic Garden and Botanical Museum Berlin-Dahlem (B 10 0243031, B 10 0243032), and the specimen deposited by Bachulkar (MPB-4722).

Begonia hirtella Link, Enum. (Fig. 1) Pl. Hort. Berol. 2: 396. 1822; Jayasuriya in Dassanayake & Fosberg Rev. Handb. Fl. Ceylon 4: 144. 1983; Bachulkar and S.R. Yadav. J. Econ. Tax. Bot. 24 (2): 293–294. 2000. *Begonia ciliata* HBK. Nov. Gen. & Sp. 7: 178. 1825. *Begonia villosa* Lindl. Bot. Reg. 15: t. 1252. 1829. *Begonia hirtella* var. *nana* A. DC. in Mart. Fl. Bras. 4 (1): 345. t. 8. 1861.

Herb. Stem erect, branched, densely villous, succulent. Leaves simple, asymmetrical, ovate, villous above and at margin, nearly glabrous below, stipule whitish-green, glabrous, lacerate or ciliate at margin; persistent. Flowers small, white, bracteate; bract ovate, laciniate, ciliate at margin. Male flowers: Tepals 4, petalloid, outer 2 tepals larger than inner 2, glabrous, Stamens 7–10. Female flower: Tepals 5, outer two larger than inner, styles 3, bifid, stigmas linear coiled, ovary winged. Fruit: capsule, wings 3; one of them larger than other two, glabrous to glandular–punctate with persistent bract, bracteole, and style; seeds numerous, elliptic ovate, brown with alveolate surface.

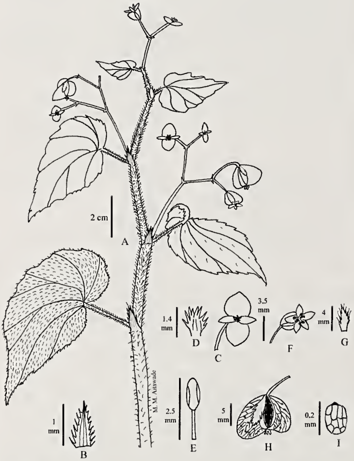

Fig. 1: *Begonia hirtella* Link: (A) Flowering and fruiting twig, (B) Stipule, (C) Male flower, (D) Bract of male flower, (E) Single stamen, (F) Female flower, (G) Bract of female flower, (H) Capsule with persistent bracteole, (I) Seed

Fl. and Fr.: August to January.

Specimens observed: MPB-4722 and MMA-4 (SUK).

Distribution: Native of Tropical America and has spread to Sri Lanka, Brazil, and India.

Notes: It grows in humid shady places. This species can be distinguished by its villousness, ciliate-lacerate stipules, laciniate bracts, and glandular-punctate capsule with persistent bracteoles. The plant is used for the treatment of certain skin inflammations such as boils.

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21. REDISCOVERY OF *ARGYREIA COONOORENSIS* SMITH & RAMAS. (CONVOLVULACEAE) AFTER A CENTURY FROM THE NILGIRIS, TAMIIL NADU, INDIA

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The Western Ghats is one of the biodiversity hotspots of the world (Mittermeier *et al.* 2005) and the Nilgiri Mountains are one of the most important centres of speciation for flowering plants in the Western Ghats (Daniels 2001). While working on a major UGC project "Inventorization, Documentation and Conservation of Endemic Angiosperms in Nilgiris", the authors explored the north-eastern part of Nilgiris which resulted in the collection of an *Argyreia* species from Kilkothagiri.

After careful examination and comparison with specimens deposited at the Central National Herbarium (CNH), Kolkata, along with relevant literature, its identity was confirmed as *Argyreia coonoorensis* Smith and Ramas. The voucher specimen is deposited in the herbarium of Department of Botany, Bharathiar University, Coimbatore (BUH). The plant was first collected by Meebold during 1910 in Coonoor, Nilgiris, which was described by Smith and Ramaswami (1913). The type specimen deposited at CAL was the only authenticated specimen available for reference in India till now. Even though the Nilgiris (and other areas of the Western Ghats in Tamil Nadu) were explored by botanists of the Botanical Survey of India, Southern Circle, Coimbatore, the species was not recorded in these explorations. However, it was included in the flora of the Nilgiris (Chandrabose 1987, Sharma *et al.* 1977) based on the collection of Meebold. In spite of its rarity, it was not included by earlier botanists (Henry *et al.* 1978; Nayar and Sastry 1987, 1988, 1990; Vajravelu and Daniel 1983) in their rare/threatened lists of South India.

Argyreia coonoorensis W.W. Smith & Ramaswami in Rec. Bot. Surv. India 6: 30, 1913; Gamble, Fl. Pres. Madras, 2: 909, 1923; Sharma *et al.*, in *Biol. Mem.* 2(1&2): 95, 1977; Chandrabose in Henry *et al.*, Fl. Tamil Nadu, Ser: I; Analysis 2: 101, 1987.

A large climbing shrub; stems grooved, clothed with hirsute hairs; leaves broadly ovate-cordate to narrow, lanceolate, 15–20 cm x 12–15 cm, nerves 10–12 pairs; sparsely pilose above, silky pubescent beneath, apex acute, base cordate; petiole 4–5.5 cm, hirsute; Flowers in few flowered (3–4 flowered) cymes; peduncles upto, 26 cm. Bracts often conspicuous, large ovate-lanceolate, thin veined pubescent, linear strigose to 2 cm. Sepals 5 equal, ovate, obtuse, strigosely hirsute 1.5 cm. Corolla bright purple with deeper throat, 7 cm long, tubular infundibuliform, the bands hairy, funnel-shaped 5 cm across, tube 5 cm long. Stamens 5 included, unequal, to 2 cm, anthers 3.5 mm. Ovary sub-sessile, style straight, stigma globose.

Ecology: Occasional along the fringes of disturbed evergreen forest.

Fl.: May–July.

Specimen Examined: INDIA: Tamil Nadu, Nilgiri district, Coonoor, Dec. 1910, Meebold, A., 12397 (CNH); Kilkothagiri, ±1,650 msl, 20.vi.2009, Ramachandran, V.S. and R. Sasi, 5071 (BUH).

We found the species growing in the wild, mostly on the fringes of the evergreen forests along with *Ternstroemia japonica* (Thunb.) Thunb., *Cyananchum alatum* Wight & Arn., *Gymnema tingens* (Roxb.) Wight & Arn., *Arisaema leschenaultia* Bl., and *Pouzolzia* sp., normally at an altitude of *c.*1,650 m above msl. It was also seen occasionally in the disturbed evergreen forest of the Eastern Nilgiris

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22. MISTAKEN IDENTIFICATION AND DISTRIBUTION RANGE OF *COMMELINA CAROLINIANA* WALTER (COMMELINACEAE) – AN ADDITION TO THE LIST OF *COMMELINA* SPECIES OF JAMMU AND KASHMIR, INDIA

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A few plants of a *Commelina* species collected from three localities of Jammu [along the banks of a freshwater canal, outside the new campus (University of Jammu), and agricultural fields of Ranbir Singh Pura and Bishnah tehsils] were transplanted in the experimental plots of the Botanical Garden, University of Jammu. While identifying the species through published floras and other literature (Hooker 1892; Prasad *et al.* 1996; Sharma and Kachroo 1981; Swami and Gupta 1998), we realised that the species, initially mistaken for *Commelina paludosa* Blume, was *Commelina caroliniana*

Table 1: Morphological characterisation of the collection of *Commelina caroliniana*

Character	Present collection	Hooker (1892)	Faden (1993)
Flowering	July/Aug. to Nov.	Not mentioned	July to Nov.
Spathe type	Peduncled, leaf opposed, ovate-cordate, not falcate	Peduncled, axillary, cordate	Not at all to slightly falcate
Upper cyme	Well-developed in spathes of older age, usually 1-flowered	Not mentioned except 1-2-fid	Usually vestigial, rarely well-developed and 1-flowered
Staminodes	Three, each 6-lobed, yellow usually with a central maroon spot	Not mentioned	Three, all with well-developed antherodes, yellow, usually with a central maroon spot
Middle anther	Connective white	Not mentioned	Connective white
Leaf length (cm)	3.6–18.9	2.6–7.2	2.5–10.5
Leaf breadth (cm)	1.2–2.9	1.3–1.8	0.7–2.4
Spathe length (cm)	1.8–3.0	1.3–2.6	2.35; Walter's record
Spathe breadth (cm)	0.7–1.2	Not mentioned	0.8
Fruit length (mm)	7–9.5	Not mentioned	(5-)6–8
Seed*			
i. Length (mm)	3.8–5.5	Not mentioned	2.4–4.3(-4.6)
ii. Breadth (mm)	1.8–3.0	Not mentioned	(1.6-)2.0–2.3
Chromosome number	2n=90	Not mentioned	2n = *c*.86

*Posticous (Ventral locule)

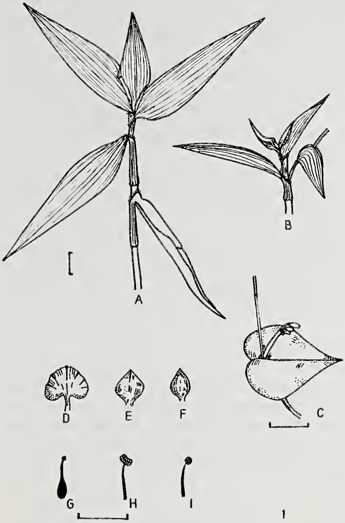

Fig. 1: *Commelina caroliniana* Walter: A. Branch; B. Spathe; C. Spathes with margins drawn apart showing the lower cyme; D. Petal; E. Anterior petal; F. Sepal; G. Pistil; H. central stamen; I. Lateral stamen. Scale bars: a–b = 1 cm, c =1.8 cm, d–i = 2.3 cm.

Walter (synonym *C. hasskarlii* Clarke). The identity of the species was further confirmed by Dr. Robert Faden of the Smithsonian Institution, USA. Voucher specimens were deposited at the Smithsonian Institution, and Botanical Survey of India, Kolkata, India.

C. caroliniana had not been recorded earlier from Jammu and Kashmir (Dhar and Kachroo 1983; Kachroo *et al.* 1977; Kapur and Sarin 1990; Kaul 1986; Murti 2001; Sharma and Kachroo 1981; Singh *et al* 2002; Swami and Gupta 1998), and hence, this was the first report for the state (Kaul and Koul 2007). With this, the number of species of the genus *Commelina* in Jammu division increased to four; the others being *C. benghalensis* L., *C. kurzii* Clarke and *C. paludosa* Blume (Sharma and Kachroo 1981; Swami and Gupta 1998). Till this record, *C. caroliniana* was reported from the upper Gangetic plains; Kumaon and from Delhi eastwards to Assam and Bengal, and, southwards to the Deccan peninsula (Hooker 1892). With the recent report of its occurrence in Jammu (Kaul and Koul 2007), the northern limit of its distribution range has extended to the Shiwaliks.

Commelina caroliniana Walter

C. caroliniana grows in varying habitats such as fields, roadsides, yards, and other such places wherever moisture is available. It frequently grows as a weed in rice, maize, and sugarcane fields (Faden 1993; Kaul 1998). Morphological details of the plants (Fig. 1) collected by us are summarised below.

Stem much branched, 68–169 cm long, scandent or decumbent. Roots arise at nodes also, particularly at the lower ones. Leaves 3.6–18.9 x 2–2.9 cm, large, dark green, glabrous or puberulous, narrowly lanceolate, alternately arranged with sheathing bases and entire margins, apex acute to acuminate, 3–9 times longer than broad. Inflorescence a cincinnus borne within solitary leaf opposed spathes 1.8–3.0 cm long and 0.7–1.2 cm broad, margins free to the base, not at all to slightly falcate, lacking contrasting veins, bright green, puberulous, peduncles 1.1–2.5 cm, ovate-cordate and longer than broad. Flowers borne in two separate cymes; upper cyme single (male) flowered, exserted; lower 3–4, (-5) flowered, hermaphrodite. Flowers trimerous, zygomorphic and chasmogamous. Sepals 0.4–0.5 x 0.2–0.4 cm, membranous, transparent and ovate, the two anterior ones larger than the posterior one. Petals 0.5–1.1 x 0.4–0.9 cm, all blue to bluish-violet and clawed; anterior petal small 0.74 x 0.61 mm, ovate-obovate, and pointed at the tip. Androecium-3 large fertile and 3 small vestigial stamens. Anthers dimorphic; the central one 1.6–1.97 x 0.95–1.2 mm, long, curved, bright yellow and versatile; two lateral 1.0–1.3 x 0.87–1.06 mm, straight, yellow and basifixed, filaments 6.0–11 mm long, curved. Anthers of staminodes bright yellow, usually with a central maroon spot, 6-lobed, variable in size and shape, borne on 4–7 mm slender filaments. Gynoecium 7.5–9.5 mm long, tricarpellary syncarpous; ovary trilocular, light green to greenish-white bearing trichomes on its surface, mucilaginous; style long, light to whitish-green terminating into a 3-fid violet stigma; ovary 5-ovulate; two in each anticous (dorsal) and one, which is the largest, in posticous (ventral) locule. Fruits glabrous, green, trilocular 7–9.5 x 3–4.5 mm when dry, slightly pointed at distal end. Dehiscence loculicidal; two anticous chambers emptied simultaneously; posticous locule indehiscent. Seeds 5, 2 in each anticous and 1 in posticous chamber, smooth to faintly alveolate, cylindric-conic mealy. Chromosome number 2n=90; meiosis I & II normal.

Fl. and Fr.: Last week of July or first week of August to November.

All the features elaborated above, together identify the study material with *Commelina caroliniana*. The chromosome number of the plants (Kaul 1998; Kaul and Koul 2007, 2008; Kaul *et al.* 2007) also agrees with that reported by Raghavan and Rao (1961), and Kammathy and Rao (1961a, b) for *C. hasskarlii* Clarke (Fedorov 1969), which is a synonym of *C. caroliniana*.

The morphological details of *C. caroliniana* recorded by us were compared with those given by Hooker (1892), and Faden (1993) – see Table 1. As is evident from Table 1, there are many distinct differences in some quantitative as well as qualitative traits. Despite these differences, the plants collected and described here conform to the description of *C. caroliniana*. The presence of significant differences in the majority of the quantitative features, probably due to geographical factors, is suggestive of the Jammu collection as being an addition to the existing germplasm of *C. caroliniana*.

Commelina caroliniana, native to India and Bangladesh, is an introduced species in United States where it was first described by Thomas Walter in 1788 in Flora Caroliniana (Faden 1989). The species was, however, treated differently by different workers: it was treated as a synonym of *C. communis* by some (Vahl 1805–1806), *C. diffusa* by C.B. Clarke in 1881 and Duncan and Kartez in 1981; a distinct species by Muhlenberg in 1818 and doubtful by A. Radford in 1968 (Faden 1989 and references therein). Robert Faden's detailed research on Walter's original description and specimens established the species to be different from *C. diffusa*. Later, he noticed that *C. caroliniana* was identical to a species found in India, namely *Commelina hasskarlii* described and named by Charles Baron Clarke in 1874 nearly a century after Walter's work. According to Faden, *C. caroliniana* must have been introduced to the United States because it was closely related to several Old World species of *Commelina* more than any North American species. Subsequently, he proposed that *Commelina hasskarlii* Clarke is a synonym of *C. caroliniana* (Faden 1989, 1993, 2000). In India, the species is still being erroneously referred to as *C. hasskarlii* (Karthikeyan *et al.* 1989; Prasad *et al.* 1996) despite Faden's (1989, 1993) repeated elaborations on the matter. Lack of updating the available literature by the authorised agencies can lead to serious implications in research.

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23. *ZINGIBER ROSEUM* (ROXB.) ROSCOE – AN ADDITION TO THE FLORA OF MAHARASHTRA, KARNATAKA, AND GOA (INDIA)

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Introduction

Genus *Zingiber* Mill. (Zingiberaceae) is represented by 141 species (Theilade 1999; Theilade and Mood 1999) distributed mainly in tropical Asia. Six species have been reported from Maharashtra (Sharma *et al.* 1996), 8 in Karnataka (Sharma *et al.* 1984; Bhat 1993), and 4 in Goa (Rao 1986). Sabu (2006) recently revised the Zingiberaceae of southern India and reported 7 species of *Zingiber* to occur in the northern Western Ghats.

During our survey of the Northern Western Ghats, *Zingiber roseum* (Roxb.) Roscoe was collected from three sites, namely Belgaum district (Karnataka), Sindhudurg district (Maharashtra), and North Goa district (Goa). This species is a new record for the Northern Western Ghats and for the three states, namely Maharashtra, Karnataka, and Goa. The voucher specimens of the species were deposited at the herbarium of the Botany Department of Shivaji University, Kolhapur (SUK).

Zingiber roseum (Roxb.) Roscoe, Trans. Linn. Soc. London 8: 348. 1807; Roxb., Asiat. Res. 11: 347. 1810, Fl. Indica 1: 49. 1820; Baker in Hook. f., Fl. Brit. India 6: 244. 1892; K. Schum. in Engler, Plfanzenr. 4(46): 184. 1904; C. E.C. Fisch. in Gamble, Fl. Madras 8: 1489. 1928; Manilal, Fl. Silent Valley 314. 1988; M. Sabu, Zingiberaceae & Costaceae of South India, 244. 2006. *Amomum roseum* Roxb., Pl. Coast Coromandel 2: 15 pl. 126. 1800.

Rhizome thick, fleshy white to pale yellow within; roots many, fleshy. Leaf shoot *c.* 1.2 m tall, basal portion enclosed by long sheaths. Leaves short, petiolate; ligule bilobed, *c.* 1.8 cm long, membranous; lamina *c.* 25 x 8 cm, oblong-lanceolate, tip acuminate, base rounded, lower surface pubescent, upper surface glabrous. Inflorescence produced directly from the rhizome, almost buried in the soil; peduncle very short or absent; spike *c.* 5 cm long, oblong, dense. Bracts *c.* 5 cm long, broadly ovate, closely imbricating, red. Bracteole shorter than the bracts, linear-lanceolate, slightly notched at the tip, sparsely hairy. Flower *c.* 3 cm long, pale yellow. Calyx tubular, membranous, tip slightly toothed. Corolla tube longer than the bracts, *c.* 5 cm long, white, segments subequal, red; dorsal lobe 2.5 cm long, recurved; lateral lobes smaller, linear. Labellum shorter than the corolla lobes, oblong-cuneate, slightly three-lobed, margin recurved, crisp, white, sometime with yellow markings on side lobes. Lateral staminodes very small, rounded yellow. Anther sessile; thecae *c.* 1 cm long; crest *c.* 7 mm long. Style long, filiform, stigma ciliate. Epigynous glands small, free from each other. Ovary 4 mm long, pubescent. Capsule ovoid-elliptic, red trigonous; seed black, *c.* 6 mm long.

Fl. & Fr.: July–October.

Specimen Examined: Karnataka: Belgaum- Amgaon and Kankumbi. ANC-774. Maharashtra: Sindhudurg- Amboli. ANC-1271. Goa: North Goa- Chorla Ghat. ANC-811.

Note: This species can be distinguished by its lateral spike, from the base of leafy stem; peduncle very short or absent; labellum white or with yellow markings. The species prefers evergreen forests at high altitude, growing in association with *Costus speciosus* (Koenig) Smith. The plants were planted in the botanic garden of the Department of Botany, Shivaji University, Kolhapur.

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24. *AERIDES ROSEA* LODD. EX LINDL. & PAXTON (ORCHIDACEAE) – A NEW RECORD FROM THE ANDAMAN AND NICOBAR ISLANDS, INDIA

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The Andaman and Nicobar Islands in India is a repository of diverse plant species, including 125 species of orchids of which 25 species are endemic to this group of islands (Singh *et al.* 2003). There are 47 plant species on these islands, which do not occur on mainland India.

During a cursory visit to the middle Andamans in February 2009, an epiphytic orchid was collected from the beach forest of the Vandoor Marine Park. The habit of this species resembled *Aerides multiflora* Roxb., except that the inflorescence (of the previous year) of this plant was arched, not pendulous, as in the latter species. This plant flowered under cultivation in the orchidarium of the Regional Plant Resource Centre (RPRC) at Bhubaneswar during April 2010 and May 2011. It was identified as *Aerides rosea* Lodd. ex Lindl. & Paxton, popularly known as Fox Brush plant. *Aerides rosea* is known to occur in mainland India, but not from the Bay Islands. The scientific illustration (Fig. 1a–k and Fig. 2a–c) along with morphological description for this species is provided here.

Aerides rosea **Lodd. ex Lindl. & Paxton**

Paxton's Fl. Gard. 2: 109, t.60.1853; Seidenfaden, Opera Bot. 95: 249. 1988; Chowdhery & Pal, Orch. Arunachal Pradesh: 14. 1997; Pradhan & Pradhan, Beaut. Him. Orch.: 30. 1997; Kumar in Pathak *et al.* (ed.), Orch. Sci. & Com.: 111. 2001; Deb *et al.*, J. Orchid Soc. India 17(1-2): 7. 2003; Pearce & Cribb, Orch. Bhutan: 495. 2002. *Aerides fieldingii* B.S. Williams, Orch. Grow. Man. 2.ed.: 39. 1862; Hook.f., Fl. Brit. India 6: 45. 1890; Fischer, Rec. Bot. Surv. India 12(2): 135. 1938; Panigrahi, Proc. Nat. Acad. Sci. India Sect. B 36: 127. 1966. *Aerides williamsi* Warner, Sel. Orch. Pl. 1: 21. 1862; Pradhan, Ind. Orch. Guide to Iden. Cult. 2: 546. 1979; Hegde, Orch. Arunachal Pradesh: 71. 1984. *Aerides multiflora* auct. non Roxb. Corom. Pl. 3: 63, t.271. 1820; Dev & Naithani, Orch. Fl. North West Him.: 361, t.205. 1986.

Type: india: Meghalaya (Jaintea Hills), *sine loc.* Loddiges 1530 (holo K-LINDLEY)

Morphological description: Scattered epiphytes with monopodial growth habit. Stem erect 10–15 cm long, 13–15 mm thick, clothed with leaf bases, rooted below. Roots terete, 4-5 mm thick. Leaves strongly arched, deeply channeled, narrow-oblong, slightly tapered to the unequally rounded bifid mucronate apex, fleshy, 12–35 cm long, 16–30 mm wide. Inflorescence one to two per plant, axillary, simple, or with a small (5–9 cm long) branch at the base, arched; peduncle 5.5–13 cm long, 2.5–4 mm thick, with two sheathing tubular and one deflexed brown sterile bract; raceme dense flowered 10–40 cm long, 3.5–4 cm across. Floral bracts oblong-lanceolate, acute, brown, persistent, 4.75 x 2.5 mm. Pedicel and ovary 16 mm long, four-angled, pinkish-white. Flowers pale rose, fragrant, 13.5–20 mm across. Dorsal sepal elliptic-obovate, apiculate, 8 x 5.5 mm, 5-veined; lateral sepals broadly and obliquely ovate, obtuse, 5-veined, 6.5 x 6.5 mm. Petals obovate-oblong, obtuse, 3-veined, 7.5 x 4.4 mm. Lip continuous with the column-foot, immovable, 3-lobed,

Table 1: Key morphological features of *A. multiflora* and *A. rosea*

Feature	*A. multiflora*	*A. rosea*
Leaves	Turn purple-red in dry season	No change in colour in dry season
Inflorescence	Pendulous, mostly simple	Arched, simple, or often branched
Pedicel and ovary	5–7 mm long, 3-angled	16 mm long, 4-angled
Flower	Perianth purplish white with purple-pink blotches; lip purple-pink; inodorous	Perianth pale rose; pleasantly fragrant
Lip Midlobe	Cordate, apex truncate, rounded	Triangular, apex sub-acute
Spur	Back wall right-angled	Back wall stretched forward in a slope

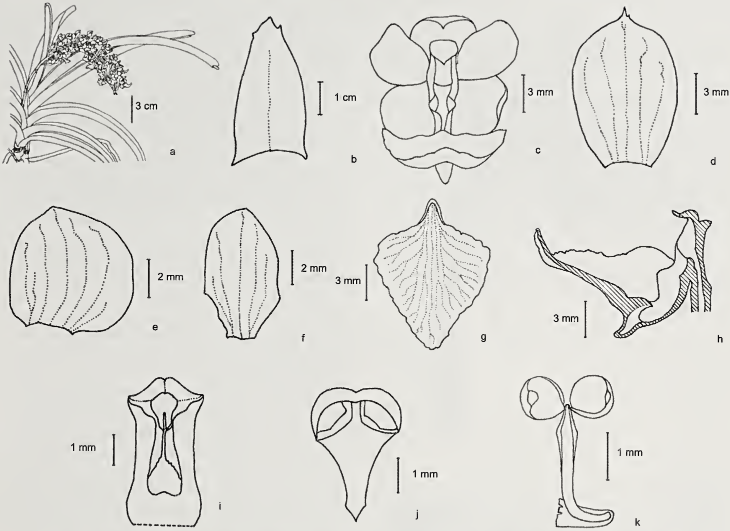

Fig. 1: *Aerides rosea* Lodd. ex Lindl. & Paxton: a. plant, b. bract, c. flower, d. dorsal sepal, e. lateral sepal, f. petal, g. lip, h. section through column and lip, i. column, j. operculum, k. pollinarium (after S. Misra TOB 463; drawing and inking: S. Misra).

spurred; midlobe pointing forward, triangular, sub-acute, margin undulate, 5-veined, 10 x 10 mm; spur porrect, very short, broadly conical, 2 mm long; lateral lobes small, incurved over entrance to the spur. Column 5 mm long, 2–2.5 mm wide, winged along the stigmatic slit. Stigma narrow-triangular; rostellum beaked, bifid above with a narrow slit in between. Anther depressed, cream-coloured, narrowly ovate in outline, apiculate, 4 x 2 mm, 2-chambered, each chamber with a broad-ovate-truncate flap covering the pollinia. Pollinia two, yellow, globose, deeply foveolate, each 0.8 mm across; stipe linear, upper portion folded in, 2.8 mm long; viscidium foot-shaped, 1.2 mm long. Capsules obovoid, ridged, shortly stalked, 15 x 8 mm.

Flowering: April–May; lasting for about three weeks.

Ecology: In tropical seashore forest, in open condition, at low heights in Andaman; elsewhere in montane evergreen forests.

Occurrence: Middle Andaman, Vandoor marine park; occasional.

Distribution: INDIA: Uttarakhand, Sikkim, Meghalaya, Arunachal Pradesh, Nagaland, Andaman and Nicobar Islands; Bhutan; Bangladesh; Myanmar; China; Thailand; Laos; Vietnam.

Specimens examined in CAL:

INDIA: Meghalaya (Jaintea hills). Prain's collector 75 (2 sheets); Khasia. Coll.: R. Pantling *sine no.* (both labelled *Aerides fieldingii*). Sikkim: Coll.: R. Pantling 446 (labelled *Aerides multiflora*). Assam: *sine loc. Mann. Sine no.* (labelled *Aerides fieldingii* by Mann and determined as *Aerides multiflora* by R. Pantling). Eastern Himalaya: *sine loc.* Coll.: *Griffith* 5223 (labelled as *Aerides multiflora*). Andaman & Nicobar Islands: Middle Andaman, Vandoor Marine Park. Coll.: S. Misra TOB 463; under cultivation at RPRC. BANGLADESH: Sylhet: Coll.: C.B. Clarke 7173 (labelled as *Aerides affine*; determined as *Aerides multiflora* by R. Pantling).

There is no representation of this species under the name *Aerides rosea* in CAL. A few specimens labelled / determined

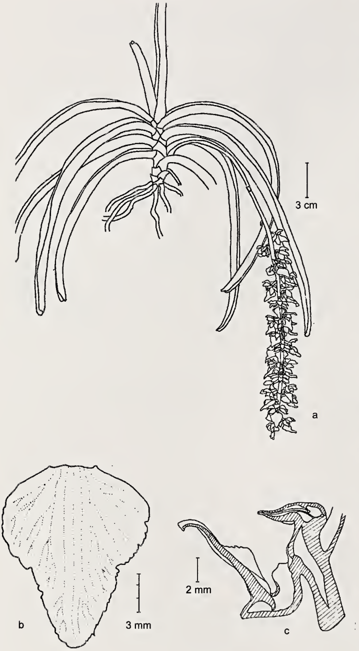

Fig. 2: *Aerides multiflora* Roxb.: a. plant, b. lip, c. l.s. through column and lip

as *Aerides fieldingii* or *Aerides multiflora* were robust plants (Griffith 5223 leaves are 35 cm long, 30 mm wide; inflorescence 53 cm long, peduncle 4 mm thick); inflorescence branched and the midlobe of the lip appeared triangular, acute. C.B. Clarke provided a sketch of the lip where the midlobe is triangular, acute, instead of cordate, obtuse, and identified as *Aerides rosea*. The flowers here are however, medium sized (15–20 mm) and the pedicel is only 7–8 mm unlike 16 mm long in the Andaman plants. A plant from the Kachin hills of Myanmar, with a branched inflorescence was identified by R. Pantling as *Aerides fieldingii*. We have not included this under *Aerides rosea* as this specimen lacked flowers.

Taxonomic note: This plant was originally collected by Loddiges and grown in Kew Gardens. Paxton prepared a plate for this, which is now in the Kew Herbarium. Authors in the past have separated *Aerides rosea* from *Aerides multiflora* in many ways. According to J.D. Hooker (1890), *A. rosea* is a much more robust plant; the midlobe of the lip is hastate, with an acute apex, while in *A. multiflora* the midlobe of the lip is hastately ovate and its tip rounded. King and Pantling (1898) too opined that *A. rosea* is a more robust plant with wider, flat leaves; larger flowers; according to them, it was not recorded from Sikkim. Kumar (2001) has included *A. rosea*.

Seidenfaden (1988) separated the above two species and provided text figures and photographs. According to him, the midlobe of the lip is triangular, acute in *A. rosea* but heart-shaped, tip emarginate-truncate in *A. multiflora*. According to Pradhan and Pradhan (1997), who too have provided photographs for these two plants, *A. rosea* has larger (30 mm), rose-purple coloured flowers; the 30–60 cm long flower spike is often branched. *A. multiflora* is a dwarf plant, often forming large clumps that can measure 90 cm across; the flowers are smaller (20 mm), white, flushed with purple-pink. According to Pearce and Cribb (2002), in *A. rosea*, the midlobe of the lip is triangular, apex acute; pedicel and ovary more than 10 mm long. In *A. multiflora*, the midlobe of the lip is cordate, apex emarginate-truncate; pedicel and ovary less than 10 mm long.

Deva and Naithani (1986) have examined many specimens from north-west Himalaya. They have provided two different figures: midlobe of lip cordate, rounded (fig. 204) and midlobe triangular, acute (fig. 205) for the Garhwal plants from Ajabpur (Deva 2589) and Rajpur (Deva 2950) areas respectively. They have treated both these under *A. multiflora* and suggested cytotaxonomic study for distinguishing one from the other. We are of the opinion that the specimens from Rajpur, with a triangular midlobe of the lip are *A. rosea*. *Aerides multiflora* is a common orchid and found in a number of habitats in Orissa. This is a medium-sized plant growing in scattered condition; sometimes older plants of these form tufted clumps.

We have examined a live specimen of *A. rosea* from only one locality in the Andaman Islands. The habit of this plant is more or less similar to *A. multiflora*; it is not a robust plant as those observed on the Indian mainland. The various morphological features examined by us and tabulated below indicate that *A. rosea* is a good and uncommon species. It forms now a new record to the flora of the Andaman and Nicobar Islands.

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25. NEW RECORDS OF WILDLIFE FROM THE CHITTAGONG HILL TRACTS OF BANGLADESH

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The Chittagong Hill Tracts (21° 25'–23° 45' N; 91° 54'–92° 50' E) is the most remote and least explored area in Bangladesh. It is situated in the southeastern part of Bangladesh along the borders of Mizoram and Tripura states of India, and Myanmar. The total area is about 13,184 sq. km, which is divided into three administrative districts, namely Khagrachari, Rangamati, and Bandarban. The Chittagong Hill Tracts (CHT) is in the western end of Indo-Burma Biodiversity Hotspot (Conservation International 2012) at the confluence of two biogeographic sub-regions: Indo-Himalaya and Indo-China. The area is mostly hilly, covered by natural evergreen forests, bamboo, bush, and reeds, as well as shifting cultivation and plantations of timber trees. The climate is the tropical monsoon type with mean annual rainfall about 2,540 mm. Hills of the CHT are the highest elevation areas in Bangladesh, with Saka Haflong (or Tlangmoi) peak in the Bangladesh-Myanmar border having the country's highest elevation (more than 1,000 m). The human population density is the lowest in Bangladesh.

Due to its remoteness and low population, the biodiversity of the CHT is rich but is still unexplored, as indicated by the records of five vertebrate wildlife species new to Bangladesh which were recorded from November 2010 to November 2011. These species were recorded from sightings and photographs, and through capture and recording of measurements in the case of frog species. These comprise of a squirrel, a bat, a turtle, and two frog species. All the five new records were published, with colour photos, in the most popular daily newspaper of Bangladesh *Prothom Alo* (December 04, 2010 for the two mammals, October 10, 2011 for the two frog species, and December 23, 2011 for the turtle). These species are not listed in the recent checklists of wildlife of Bangladesh (Ahmed *et al.* 2009a; Kabir *et al.* 2009; Khan 2008; Khan 2010). Among the other sightings are those of several rare species of bird and a frog. The new records and other interesting sightings are discussed in this article:

A Himalayan Striped Squirrel *Tamiops macclellandi* was found foraging along the branches of a medium-sized tree in evergreen forest on a slope of Capital Hill (21° 53.33' N; 92° 31.49' E) in Theikkang, Ruma, Bandarban, on November 22, 2010, in the morning. It was a small squirrel with a relatively big head and greyish brown back with four black, brown, and buff stripes, which agrees with the characteristics of the Himalayan Striped Squirrel. It was significantly smaller than the other two striped squirrels of the region: Indian Palm Squirrel *Funambulus palmarum* and Northern Palm Squirrel *F. pennantii* (Menon 2003; Prater 1980). The nearest known distribution of this species is in north-east India (Menon 2003).

A colony of about 40 Least Leaf-nosed Bat

Hipposideros cineraceus, together with a few Blyth's Horseshoe Bat *Rhinolophus lepidus*, was seen inside Boga Cave (21° 58.95' N; 92° 28.59' E) in Ruma, Bandarban, on November 20, 2010. The area surrounding the cave had dense vegetation. The species was differentiated from Blyth's Horseshoe Bat and other small cave-bats of the region by its very small size, very pale (almost white) orange coat in underparts, and the very small leaf-nose (Bates 1997; Menon 2003). The nearest known distribution of this species is along the Himalayan foothills in north-east India (Bates 1997; Menon 2003).

A young Asian Softshell Turtle *Amyda cartilaginea* was found in shallow waters of a rocky hill-stream called Remakri Khal (21° 50.94' N; 92° 34.11' E) in Thanci, Bandarban, on November 17, 2011. Later, another freshly hunted adult was seen with an ethnic Mru turtle hunter downstream. The hunter was hunting for more by jabbing his metallic spear in the mud of a stream bed. I also came across a group of three turtle hunters, who were doing the same, and was informed that they occasionally hunt this turtle and another turtle species (presumably Leaf Turtle *Cyclemys* sp., based on their description) from the stream. Later, a large shell of Asian Softshell Turtle was seen in a nearby Mru village (Nepew Para). Both the live and the freshly hunted specimens had the characteristic low carapace with rounded sides, and with tubercles at the anterior margin and numerous folds all along the carapace; relatively narrow head, and long and slender snout. These characteristics differentiate the species from other softshell turtles of the region (Ahmed *et al.* 2009b; Das 2010). The nearest known distribution of the species is in Myanmar and Northeast India (Ahmed *et al.* 2009b; Das 2010).

Several specimens of Anderson's Bush Frog *Philautus andersoni* were seen in evergreen and plantation forest undergrowth in Kaptai National Park (22° 30.13' N; 92° 11.67' E), Rangamati, in June and July 2010. All were located in the evening when they start calling from leaves or narrow branches of the undergrowth, usually between 0.5–1.5 m above the ground. The call was a sharp *tok, tok, tok*. Two specimens were captured for detailed morphometry. Snout to vent length was 24 and 25 mm, respectively, which are similar to the known snout to vent length of the species (Chanda 2002). Olive or yellowish olive upperparts and whitish underparts. Only one specimen had a broad white inter-orbital band. Notably, two of the 24 specimens collected from Shillong, Meghalaya, India, were reported to have white marking on the median dorsal part (Pillai and Chanda 1979), but not the white inter-orbital band. However, since all other characteristics were the same as other specimens of Anderson's Bush Frog, namely "A narrow fold of skin from the posterior corner of eyes up to the shoulder. Head broader than long and slightly depressed. Nostrils much closer to tip of snout than to eyes. Tibio-tarsal articulation reaches the anterior corner of the eye. First finger slightly shorter than second. Toes free with swollen tips", I have identified it as the same species. No other species under the genus *Philautus* were ever found, but the East Himalayan Bush Frog *P. annandalii*, Shillong Bush Frog *P. shillongensis*, and Garo Hills Bubble-nest Frog *P. garo* are expected to occur in Bangladesh. Anderson's Bush Frog is much larger than these three species, and moreover, the Garo Hills Bubble-nest Frog has very dark upperparts, which is unique to the species. The nearest known distribution of Anderson's Bush Frog is in Northeast India and Myanmar (Ahmed *et al.* 2009b; Chanda 2002).

Two Nicobarese Frog *Hylarana nicobariensis* were found in a small ditch at the top of a bushy and cultivated hill in Moyu (22° 06.18' N; 92° 19.14' E), Roangchari, Bandarban, on November 16, 2010, during a night search. They were found floating on water and calling. The call was loud. One specimen was captured for detailed morphometry: "Snout-vent length was 49 mm. Yellowish-brown upperparts with large dark markings and whitish underparts. Dark sides of head. Limbs with dark cross-bands. A prominent glandular dorso-lateral fold from above the tympanum to the hip. Very distinct tympanum. Long and slender hindlimbs. Tibio-tarsal articulation reaches the tip of snout. Tips of fingers dilated into small discs. First finger longer than second and third finger longest. Fingers free, toes two-thirds webbed. Prominent subarticular tubercles in toes." These characteristics confirmed its identification as the Nicobarese Frog, and also differentiated it from other *Hylarana* species of the region (Chanda 2002). Unlike this species, the Taipeh Frog *H. taipehensis* and Leaf Frog *H. tytleri* have greenish upperparts and white dorso-lateral fold (Chanda 2002; Kabir *et al.* 2009). The nearest known distribution of Nicobarese Frog is in Northeast India and Thailand (Ahmed *et al.* 2009b; Chanda 2002).

A Mountain Hawk-Eagle *Spizaetus nipalensis* was seen soaring above Keokradong Range (21° 55.33' N; 92° 30.52' E), Ruma, Bandarban, on November 21, 2010. Another was seen soaring above the Capital Hill (21° 54.11' N; 92° 31.78' E), Ruma, Bandarban, on November 22, 2010. Both were large with long white-tipped crest and pale wing coverts. In flight, wings were short, square-tipped and heavily banded below and on the tail. Heavily streaked breast, and banded flanks and belly. These characteristics helped differentiate it from the similar Changeable Hawk-Eagle *S. limnaeetus* and Crested Hawk-Eagle *S. cirrhatus* that are found in the region (Grimmett *et al.* 1998; Rasmussen and Anderton 2005). This is the second sighting of the species in Bangladesh – the previous sighting was in November 2009 in Belaichari, Rangamati (Halder 2010).

An adult male Grey Peacock-Pheasant *Polyplectron bicalcaratum* was seen on a slope of hill beside a stream in evergreen forest in Rampahar (22° 30.44' N; 92° 10.53' E), Kaptai National Park, Rangamati, on April 09, 2010. It was calling at that time. The call was recorded instantly and replayed from the stream to which it responded on several occasions and approached the spot where the call was replayed. After about an hour when I was at the top of a forested hill about one kilometre north-west of the previous spot, I heard the call of a second bird. I replayed the call. The bird stopped calling and after a few minutes it was suddenly seen crossing the narrow trail that I was following. In the next few days, I heard the calls at two more sites (Sitapahar and Rangamati Road) in Kaptai. In May 2011, I visited the same spots and heard calls at three sites. These indicate the presence of a small breeding population of Grey Peacock Pheasant in Kaptai. The only previous recent sighting of this species in Bangladesh was in Babuchara, Khagrachari, in March 2001 (Halder 2010) after the report in 1888 (Hume 1888).

A flock of eight Long-tailed Broadbill *Psarisomus dalhousiae* was seen foraging along the middle canopy, and calling mildly, in a thick forest patch in Capital Hill (21° 53.33' N; 92° 31.49' E), Ruma, Bandarban, on November 22, 2010. The only recent previous sighting of the species in Bangladesh was in eastern Neikkhongchari, Bandarban, in April 2010 (Halder 2010), after the report in 1888 (Hume 1888).

A subadult (partially rufous belly and white underwing coverts) Rufous-bellied Eagle *Hieraaetus kienerii* was seen soaring above Ruilui Hill (23° 22.55' N; 92° 17.64' E), Sajek, Rangamati, on September 29, 2011. An adult was seen soaring above Tadjingdong Hill (21° 48.96' N; 92° 31.82' E), Thanci, Bandarban, on November 20, 2011. The only previous sighting of this species in Bangladesh was in Inani, Cox's Bazar, in March 1994 (Thompson and Johnson 2003; Siddiqui *et al.* 2008).

An adult Large Tree Frog *Rhacophorus maximus* was found in dense vegetation at a hill-slope in Theikkang (21° 54.37' N; 92° 31.99' E), Ruma, Bandarban, on February 18, 2011. It was captured for thorough morphometry: "Snout-vent length was 115 mm. Leaf green upperparts and white underparts with brown reticulation ventro-laterally. White lower jaw. Skin mainly smooth. Large head with distinct tympanum. Digits with large discs; fully webbed." No other *Rhacophorus* species of the region is as large as this. The only previous sighting of this species in Bangladesh was in eastern Srimangal, Moulvibazar, in December 2008 (Chakma 2009).

Other than the above-mentioned species, I saw a number of species in the Chittagong Hill Tracts from November 2010 to November 2011 that are rare in Bangladesh or have been subjected to fewer recent sightings. These include Hodgson's Giant Flying Squirrel *Petaurista magnificus* and Assam Macaque *Macaca assamensis* among the mammals; White-cheeked Partridge *Arborophila atrogularis*, Pale-headed Woodpecker *Gecinulus grantia*, Great Slaty Woodpecker *Mulleripicus pulverulentus*, Great Barbet *Megalaima virens*, Oriental Dwarf Kingfisher *Ceyx erithacus*, Grey-headed Parakeet *Psittacula finschii*, Pin-tailed Green-Pigeon *Treron apicauda*, Silver-breasted Broadbill *Serilophus lunatus*, Orange-bellied Leafbird *Chloropsis hardwickii*, Maroon Oriole *Oriolus traillii*, Scaly Thrush *Zoothera dauma*, Plumbeous Water Redstart *Rhyacornis fuliginosus*, Grey Bushchat *Saxicola ferrea*, Chestnut-bellied Nuthatch *Sitta castanea*, Black Bulbul *Hypsipetes leucocephalus*, White-hooded Babbler *Gampsorhynchus rufulus*, Striated Yuhina *Yuhina castaniceps*, Common Rosefinch *Carpodacus erythrinus* among the birds, and Northern Trickle Frog *Occidozyga borealis* and Puddle Frog *O. lima* among the amphibians.

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